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ON BEHALF OF THE ANATOMICAL SOCIETY OF GREAT BRITAIN AND IRELAND

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II. On Criteria for the Existence of Differential Deathrates. By Karl Pearson, F.R.S., and J. F. Tocher, D.Sc.

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PROCEEDINGS OF THE ANATOMICAL SOCIETY OF GREAT BRITAIN AND IRELAND

DECEMBER 1915.

THE ANNUAL GENERAL MEETING of the Society was held on December 3, 1915, at the London Hospital Medical College. The President, Professor HOWDEN, occupied the chair.

(1) Professor E. FAWCETT demonstrated several models of developing chondrocrania, among which were those of calf embryos of 25 and 19 mm., ferret embryos of 25 and 19 mm., and a mole of 19 mm.

A summary of Professor Fawcett's contributions will be found at the end of the *Proceedings*.

(2) Dr W. C. M'KENZIE demonstrated his paper on "The Attachments of Duodenum and Transverse Colon."

Among the Marsupials three folds are noted:—

1. *Mesial Fold*, well marked in koala, and connecting the colon to the pyloric region. This corresponds to the separation of the colon into right proximal, or mesenteric, and left distal, primary, or mesocolic colon. As showing its connection with the ventral mesentery, in the chameleon this fold is noted crossing the pylorus to be continuous with the gastro-hepatic omentum or ventral mesogaster. There is also evidence of this in Macropodidæ and Cheiroptera.

2. *Left Lateral* (lieno-mesocolic fold).—This is well seen in the platypus. It passes from the shorter left posterior process of the spleen to the left aspect of the mesocolon of the left colon. On this fold is suspended the left, frequently the greater, part of the pancreas.

3. *Right Lateral* (duodeno-mesocolic or duodenal fold).—This is well developed in koala and the opossum. Where we have a definite duodenal loop developed this fold passes from the ascending duodenum to the right

aspect of the mesocolon. Where the loop is not developed, the right fine extremity of the fold corresponds to the termination of the duodenum, *i.e.* a part defined by an inequality of growth between the mesoduodenum and the common mesentery, as is well shown in the Tasmanian devil. Between the duodeno-intestinal flexure, root of mesentery, and the upper margin of the fold is the primary duodenal fossa, which can be demonstrated through the Mammalia up to Platyrrhini.

1. *Mesial Fold.*—From the selection point of view, this fold is of prime importance in colon development. Proximity of the colon to the pylorus is associated with colon development to the right, *i.e.* on the mesentery. Failure of this proximity, *i.e.* poor development or absence of the band, is associated with small development of colon to the right. The extremes in Marsupialia are the koala and the carnivorous dasyures, and throughout the Mammalia varying intermediate grades are seen. The right colon —like the mesial hepatic lobe—is the experimental colon. Here we find large and small cæca-appendices—coils and loops. The somewhat complicated right colon of Rodents is simplified in the Lemuroidea, and the human type appears in the platyrrhines. In the Tasmanian devil there is no development of the colon on the mesentery, but at the junction of the small intestine and the colon (left, mesocolic) some direct branches are traced from the right vagus to the gut. Furthermore, there is evidence in Mammalia of a direct branch or branches of the right vagus to the colon on the right of the pyloric relation, *i.e.* corresponding to the division into right and left colons. It is interesting to note, as seen in Lemuroidea, platyrrhines, catarrhines, and great Anthropoids, that the fixation of the right colon, *i.e.* shortening and dorsal fixation of its common mesentery, takes place from above downwards, *i.e.* begins at the mesial attachment.

The selection sequences from the "human" point of view would be expressed as follows:—

(1) Presence of a mesial fold causing approximation of the commencement of the left, distal, or mesocolic colon to the pyloric region.
(2) Associated with this a good development of colon to right, on the common mesentery.
(3) The coils and loops seen in Rodentia and Lemuroidea are used as Nature's means for shortening the colon.
(4) Definite shortening and simplification precede fixation essential for the erect attitude.
(5) Fixation dorsally of the right colon, and so increase of the base of mesentery commences from the mesial fold, *i.e.* above downwards.

2. *Left Lateral Fold.*—The importance of this fold is in connection with the fixation of the colon in the splenic region. My explanation of its origin is that it is a *pari-passu* development with the spleen and the great omentum (*cf.* platypus), the spleen originally having, as in certain Reptilia, lain obliquely in dorsal mesogaster and mesocolon. In others the spleen involves mesogaster only, and such a spleen would not be associated with the development of this process, as in koala. On this process diffuses the left part of the pancreas (below the level of the lesser sac). For selection purposes it would not be advantageous for the pancreas to be included in the lesser sac. It would not then easily conform to the abdominal law of dorsal fixation of solids. As evolution proceeds, the upper part of the great omentum (gastro-splenic) shortens inclining spleen dorsally. Pancreas also approaches the dorsum, and result is shortening of the fold and adhesion to the kidney (lieno-renal), first to the lower pole, then the upper. The fold was originally free of kidney and dorsal wall. Thus we have proximal the spleen, pancreas, colon, kidney, and adrenal, and grades are seen in platypus, opossum, wombat, and Anthropoids. The fixation of the left colon is now further aided by secondary inclusion of the gut and its mesocolon—between pylorus and spleen—by the great omentum; and grades of this can be seen in kangaroo, platyrrhines, catarrhines, and Anthropoids. Thus the mesial band is of further importance, as this inclusion begins on the right, and it is noticeable also that the fixation of the "descending" colon begins at the splenic region and extends downwards.

3. *Duodenal or Right Lateral Fold.*—The important question in connection with this fold is what part does it take—if any—in producing duodenal shape. If we regard this band and the so-called Treitz's fold as producing shape, then we assume that they dominate function. The peculiar shape of the duodenum is the result of function force, not traction force. Shape is response to a need. In the chameleon we have evidence of duodenal shape. At this early period the duodenum becomes defined as a distinct intestinal segment. There is a distinct tucking in, representing loop commencement. Yet no membrane is present traceable to the mesocolon, so that the point of view of a band between the two acting as a traction force is out of the question. At this early period there is an inequality of growth—a failure to develop of the dorsal mesentery for the commencement as compared with that for the rest of the small intestine. Apart from gut specialisation, this inequality of growth is influenced also by growth of pancreas, spleen, and great omentum. The result of this inequality of development in the dorsal mesentery is to produce a loop or bend in the intestines at the junction of the mesenteries,

i.e. mesoduodenum and common mesentery. Owing to the presence of the mesial fold, *i.e.* the pyloric relation of the beginning of the left colon, the mesentery of the small intestine is *ab initio* ventral to the mesoduodenum, and further development of the duodenum would be to the left and dorsal to the common mesentery. As is seen throughout the Mammalia, this development does take place, and the result is an adhesion between the duodenum and the mesocolon of the left or primitive colon. From this adhesion the duodenal fold so characteristic of the Mammalia up to the Platyrrhini develops. Pancreatic development is only a minor factor in helping duodenal shape. Furthermore, throughout the Mammalia the junction of the duodenum and small intestine is an important nerve-control area receiving direct branches from the right vagus and also mixed branches of the vagus and sympathetic; and one sees the advantage of the position of the flexure in Man, since it lies dorsally near the origin of the superior mesenteric vessels. Mechanical factors probably play a part in its good development in koala, where we have a large right colon and cæcum swung on the mesentery and supported at the pylorus. A minor and later function of the duodenal loop would be to form good attachment in the looping and fixing of the right colon. So far I have failed to find evidence of nerve-carrying function of this band, and only in the bandicoot, where it is continuous with the left lateral fold in front of colon, is there a suggestion that the band is not acquired, but biological. It can be stated that the nearer we approach the single mesentery type seen in the Tasmanian devil and ant-eater, the less defined becomes the duodenal fold. In the latter it is absent, and in the comparatively simple gut of the Virginian opossum, by dividing the elongate lax mesial fold and stretching the duodenal fold, we get practically the primitive condition of the ant-eater.

To sum up, duodenal shape is a response to function, and its specialisation is associated with the entrance of direct vagal branch or branches at its termination. This latter is a constant. The site of duct entrance is not as is shown throughout the Marsupials, but it is always proximal to the vagus relation. The fold is not a biological peritoneal fold, but a secondary one and result of adhesion (zygosis). It is seen throughout the Mammalia up to Platyrrhini, is the "primary" duodenal fold, and is associated with the "primary" duodenal fossa. With the dorsal fixation of the duodenum from peritoneal adhesions, associated with fixation of right colon and its mesentery, and especially pancreas, neither fossa nor fold is seen in Catarrhini or orang.

From the comparative point of view the human-gut segments can be regarded as follows:—

1. Duodenum. Pyloric sphincter to duodenal-jejunum flexure, where we have direct vagal control.
2. Small intestine. Duodenal-jejunum flexure to termination of ileum, where we have the valve and also vagus and vago-sympathetic control.
3. From ileo-cæcal valve to large gut in relation to pylorus, practically corresponding to the entrance of direct vagal branches, is right, proximal, or mesenteric colon. This signifies origin better than terms "ascending colon" and "hepatic flexure."
4. Colon to the left of that, *i.e.* from pylorus to pelvis, is left, distal, or mesocolic colon. This signifies origin better than terms "transverse colon," "splenic flexure," "descending colon," and "sigmoid.'

In conclusion, I may mention that my researches have failed to discover throughout the Mammalia up to great Anthropoids the presence of the so-called Jackson's membrane, Lane's band, and Treitz's band. So that in my opinion these can be regarded not as biological but acquired bands—associated in Man with the erect posture.

Professors J. P. HILL, ARTHUR KEITH, and Dr CUNNINGHAM took part in the discussion of this paper.

(3) Professor WILLIAM WRIGHT exhibited numerous models which he had prepared from the viscera of the elephant. The points upon which he particularly dwelt in his demonstration were the absence of a pleural space, the peculiarities of the great venous trunks of the heart, the relation of vessels to the lungs, and the very large amount of yellow elastic tissue found throughout the body of the animal.

Professor Wright was inclined to believe that the absence of a pleural cavity was a primary condition in the elephant. He also exhibited models of the peculiar "temporal gland," and discussed its structure and significance.

Professors ARTHUR KEITH and F. WOOD JONES discussed some of the points brought out in the paper.

JUNE 1916

IN place of the usual Summer Meeting of the Society an ordinary meeting, which extended over two days (June 2 and June 3), was held at the Royal College of Surgeons, London.

The meeting on Friday, June 2, commenced at 2.30 p.m. The President, Professor R. HOWDEN, occupied the chair.

The minutes of the previous meeting were read by the Secretary.

The PRESIDENT recalled to the Society the loss suffered by the death of Sir William Turner; and he dwelt with particular emphasis upon the human side of Sir William Turner's life, since this was an aspect with which he had been in contact during an association of very many years.

Professor Howden also reminded the Society that Mr Charles Stonham, whose death had been recently announced, was one of the founders of the Society, and one of its most valued members.

(1) Dr W. C. M'KENZIE gave a paper dealing with the biology of the spleen and biliary apparatus in Monotremes and Marsupials. Dr M'Kenzie illustrated the actual conditions present in a very wide series of species, and made an exhibit of a very large number of most interesting specimens. One of the most important points brought out in this paper was the extraordinary variability of the spleen in certain Marsupials, such as the wombat. In this animal both spleen and liver show an extraordinary number of different forms, and some of these forms exhibited were strikingly human.

By the aid of this material Dr M'Kenzie demonstrated clearly the evolutionary stages of the human spleen, which had resulted in producing the notches along its anterior margin. Another very extraordinary feature, which was well displayed in the material exhibited, was the wide variety seen in the method of termination of the bile and pancreatic ducts in the intestine. The ducts may enter separately or in company, near the pylorus or far from it.

Professors F. G. PARSONS and ARTHUR KEITH took part in the discussion of this paper.

(2) Professor F. G. PARSONS recorded a series of measurements made upon nearly 300 modern English clavicles, the age and sex of which were definitely known. The first portion of the demonstration consisted of determining the relation between the clavicular length and the shoulder width. Professor Parsons then showed the results which he had obtained in endeavouring to establish an average contour for the clavicle of the male and female of modern English people. The ideal or average clavicles were recorded as permanent models, which were exhibited. Professor Parsons found that the left bone exceeded the right in length in both sexes. The last part of the paper dealt with the possibility of sexing the clavicle, and, working along the lines which he had determined from an examination of his material, he concluded that a correct diagnosis could be arrived at in 88 per cent. of cases.

A very large number of specimens was exhibited, several points of

interest being mentioned in connection with the many variations. In particular, Professor Parsons drew attention to the foramen, which not uncommonly perforates the bone.

Professor E. BARCLAY SMITH exhibited a specimen perforated by a foramen with the descending cervical nerves *in situ* in the canal, and he pointed out that, when such a condition was present, the emerging nerves appeared at the lower surface of the bone by passing through the nutrient foramen.

(3) Professor FAWCETT gave a further communication on the mammalian chondrocranium, illustrated by models. This contribution, with Professor Fawcett's other communications for 1916, is summarised at the end of the *Proceedings*.

(4) Mr V. Z. COPE gave a paper on "The Internal Structure of the Sphenoidal Sinus." It was shown that the sphenoidal sinus was by no means a simple cavity, and the presence of more or less constant septa and loculi was demonstrated. The sinus in its simplest form might occupy only a portion of the pre-sphenoid, or it might invade the post-sphenoid.

(5) Professor F. WOOD JONES gave brief abstracts of two papers. The first, dealing with the genitalia of the Cheiroptera, was subdivided into two parts, treating of the Megacheiroptera and Microcheiroptera respectively. Among the bats two main types of genitalia were described, the one having many points of affinity to that seen in the Primates, and the other reminiscent of that seen in Galeopithecus. The first type was found only among those New World bats comprised in the Phyllostomidæ. The second paper dealt with the genitalia of Tupaia, and in this animal a strange blend of almost Primate conditions with almost Metatherian features was demonstrated.

The meeting was resumed at 10.30 on the morning of Saturday, June 3, the PRESIDENT being in the chair.

(1) In the absence of Surgeon CECIL P. G. WAKELEY, a case of congenital atresia of the ileum was demonstrated by Dr R. GLADSTONE.

This anomaly occurred in a female full-term child, which was operated upon three days after birth for intestinal obstruction. At the operation a marked narrowing of the upper part of the ileum was found; the stomach and proximal part of the intestines were very distended. The rest of the small intestine beyond the constriction received its blood-supply from a pedicle of mesentery, in which the vessels were dilated

and thrombosed. Owing to the bad condition of the patient nothing further was done, the child dying a few hours afterwards. The interest of these cases lies principally in the possibility of saving life by intestinal anastomosis. In the case recorded a gastro-enterostomy was contra-indicated on account of the rest of the small intestine having a defective blood-supply, its vessels being thrombosed. It would have been useless to have performed a jejunostomy, because the child could not have lived with merely a stomach and at most twenty inches of small intestine; moreover, the condition of the jejunum was very bad, and precluded any further operative procedure.

This specimen, and others in which a considerable length of the intestine is imperforate, suggests that a twist or blocking of the mesenteric vessels, resulting in a defective blood-supply of a part of the intestine, may in some cases be the immediate cause of the arrest in its development.

(2) Dr R. GLADSTONE also exhibited, on behalf of Dr E. A. COCKAYNE, a specimen showing accessory lungs and a congenital diaphragmatic hernia which was obtained from the body of a premature female infant. The diaphragmatic hernia was on the left side, and through the opening into the pleural cavity two separate groups of organs protruded. The first consisted of the stomach, first part of the duodenum, part of the gastro-hepatic omentum, a tongue-shaped lobule of liver attached to the under surface of the left lobe, the spleen, an accessory spleen, and part of the body and the tail of the pancreas; the second consisted of the ileum, cæcum and appendix, the ascending and transverse colon with the splenic flexure and commencement of the descending colon, and the mesentery and mesocolon. The right and left kidneys and suprarenal glands lay below the diaphragm. The right lung was perfectly developed, the left had an upper and lower lobe; it was much, but proportionately, reduced in size, and normal in shape. Between the base of the left lung and the stomach were two accessory lungs in no way connected with the rest of the pulmonary system. Each was completely covered by a layer of visceral pleura, and was attached by a pedicle to the pleura covering the anterior surface of the descending aorta. Each accessory lung was larger than the whole of the left lung. The pedicle of the upper accessory lung contained two arteries, one arising from the right and one from the left side of the aorta, two veins communicating with the vena azygos major, and nerves derived from the great splanchnic. The pedicle of the lower accessory lung contained an artery derived from the descending aorta, a vein which joined the vena azygos minor, and a nerve from the

great splanchnic. Neither pedicle contained a duct in communication with the respiratory system or the œsophagus. Microscopically, in the lower pedicle, incompletely developed striped muscle was seen surrounding and running parallel to the long axis of the artery. The lower accessory lung was divided into lobules separated by connective tissue in which branches of the artery ran surrounded by similar muscle fibres. In the largest mass of connective tissue, situated centrally, was a collection of lymphoid tissue and a bronchus lined by columnar ciliated epithelium and containing plates of cartilage in its wall. The lobules were composed of very numerous bronchioles lined by columnar ciliated epithelium and a variable number of alveoli lined by cubical epithelium. The interalveolar stroma was very dense. A section through the upper accessory lung at a point distant from the pedicle showed a similar arrangement of bronchiolar and alveolar tissue. The pedicle itself and the part near the pedicle were not examined microscopically.

(3) Professor J. E. S. FRAZER demonstrated the formation of the pars membranacea septi.

In the earlier stages the bulbar portion of the heart cavity becomes continuous with the ventricular part altogether to the right of the position of the A.V. opening: subsequent alteration in relation is not the result of any change in the position of the opening, but is due to the disappearance of the bulbo-ventricular ridge and the associated left dorsal wall of the bulb. This is a necessary preliminary to the formation of the aortic vestibule, the dorsal channel made in the bulbar region by the meeting of the bulbar ridges and directed obliquely from the arterial end to the left ventricle across the fused A.V. cushions. The channel thus opens into the left ventricle through the original interventricular foramen. The pars membranacea is made from the fused A.V. cushions, the auriculo-vestibular part from the right end of the upper cushion, the interventricular part from the lower one, with some trabecular structure joining this with the proper interventricular septum. The true interventricular foramen does not close, but remains patent as the opening into the aortic vestibule from the left ventricle. The septum separating the cavities of aortic vestibule and infundibulum is made by the junction of two *bulbar ridges*, which join the free edge of the interventricular septum below: with them is a marked downgrowth of the fused lateral arterial cushions at the distal end of the bulb. Only the lower portion of the right auriculo-ventricular opening remains as the permanent opening, the upper part being closed and lying in the floor of the aortic vestibule: this upper moiety is cut off from the lower by the right bulbar ridge growing across the opening to meet the

edge of the interventricular septum. It is doubtful whether the permanent left opening is the whole or only a part of the earlier one.

(4) Dr R. H. ROBBINS, as a preliminary to a communication on the condition in other animals, demonstrated the principal markings and connections of the human pisiform, "and the general conformation which could be identified in apparently dissimilar specimens." The continuity of the outer fibres of the flexor carpi ulnaris tendon was shown with those of the annular ligament along a well-marked oblique ridge on the radial aspect of the bone. It was pointed out that any impression due to the ulnar nerve must be palmar to this ridge. The well-marked hollow, forming one of the principal features of the pisiform, and confined to the proximal portion, lies for the most part, owing to the oblique position of the bone, under cover of the tendon, and is occupied by dense fatty tissue.

(5) Dr MATTHEW YOUNG demonstrated, with the aid of a series of tables, the principal results derived from a research concerning correlation in a series of metopic skulls. The research was carried out on the West Scottish series of skulls preserved in the Anatomy Department of the University of Glasgow, which contains nearly eighty metopic skulls. These were subjected to intensive study by detailed external measurement, by working out correlations, and by analysis of the characters of the vault. The condition of the sutures was also determined.

The main results were that, with practically the same mean capacity, the metopic skulls, as compared with the normal, while retaining the same average breadth, were distinctly shorter and markedly lower. The mean capacity was maintained by increase in frontal width. The vault differed from the normal not only in the greater frontal width, but in the vertical character of the frontal region, with the bregma absolutely as well as relatively farther forwards, while there was a marked flattening behind, above, and below the lambda. Although not very decisive, the evidence regarding the sutures pointed to the closure of the sutures in the region of the lambda, at a period when all the sutures in the frontal region remained open. Metopism, therefore, is probably only one feature in a general change in the growth factors which, in the normal members of the series, determine a backward expansion, with increase in depth of the posterior part of the brain-case. The result is an exaggeration of brachycephalic characters in a brachycephalic series, and a nearer approach to the brachycephalic type in a dolichocephalic series. The evidence is against the view that the persistence of the suture is "compensatory." Metopism is not to be explained merely by an expansion of the frontal region of the brain, but more probably represents one factor in a general adjustment of the brain-

case to its contents as a whole. The sum of the changes represents a second mode of attaining a given capacity in a series of uniform type. The rarity of metopism in primitive races suggests that it is a progressive phenomenon—evidence of an instability in the adjustment between brain-mass and brain-case, or between brain-type and a capsule of stereotyped form.

Professor KEITH expressed his satisfaction at the thoroughness of the investigation, and noted the interesting fact of the absence of metopism, even as an anomaly, in anthropoid apes.

(6) Dr T. WALMSLEY gave a demonstration of certain points in the mechanism of the hip-joint.

A contrast was drawn between the mechanisms of mechanical combinations and organic joints, and in reference to the latter the following were put forward as general principles:—

1. That sections of articular surfaces at right angles to their axes of movement are not mathematical arcs;
2. That the movements within the joint are not movements of simple rotation;
3. That the whole of either articular surface is not in contact with its complement in any position of the components, but is in part in action and in part inactive or at rest.

The last conclusion was demonstrated in sections of the hip-joint in different positions of the limb through the same axis of the femoral head.

The retinacula of Weitbrecht were shown in dissections to be related to the blood-vessels of the epiphysis of the head of the femur and of the metaphysis of the neck. The opinion was advanced that their function was to control the movements of the femoral synovial pads, and that no direct morphological comparison should be made between the inferior set and the mesentery of the ligamentum teres of reptiles.

In the discussion which followed this paper Professors KEITH, FRAZER, and WOOD JONES took part.

(7) Mr ALWYNE COMPTON gave a demonstration of the intrinsic anatomy of the large nerve trunks of limbs.

The paper dealt with the sciatic trunk.

The tibial and peroneal divisions of the sciatic trunk may be so closely applied to each other that the line of union is difficult to define. In such cases the inner two-thirds correspond nearly to the tibial, the outer third to the peroneal. The peroneal division lies on a plane slightly anterior to the tibial. No nerve fibres pass from one to the other. When the fibrous

sheath has been removed, the trunk is seen to be marked by superficial longitudinal bundles. The posterior aspect of the tibial division is partly covered by a sensory tract, the posterior cutaneous nerve of the calf. The same aspect of the peroneal nerve is overlaid by another sensory tract composed of the lateral cutaneous nerve of the leg and the peroneal communicating nerve. Occupying the interior of each division in the middle third of the thigh is a plexus. The sensory tracts have little or no connection with the plexuses. All the motor bundles, however, take part in the formation of the plexuses, except the nerves to the hamstring muscles, which leave the sciatic trunk more proximally. The bundles composing the peroneal division are arranged spirally, whereas those of the tibial are practically vertical. There is no haphazard grouping of the bundles, but a definite arrangement associated with the relative position of the soft parts supplied by the bundles.

(8) Dr M. F. LUCAS exhibited and demonstrated a remarkably complete case of double inferior vena cava. The question of the underlying embryological channels involved in this anomaly was gone into, and Professor FAWCETT and Dr GLADSTONE further discussed the subject.

DECEMBER 1916

THE ANNUAL GENERAL MEETING was held at the London School of Medicine for Women on December 1, 1916. The greater part of the meeting was occupied by the Society's business. Professor HEPBURN occupied the chair. The following scientific communications were made:—

(1) Professor FAWCETT demonstrated some additional models of the developing chondrocranium, the findings from which are summarised later.

(2) Professor A. M. PATERSON gave a paper upon "The Action of the Biceps Flexor Cruris." A gunshot wound of the buttock, which divided the peroneal nerve, had produced paralysis of the short head of the biceps, while the long head, in common with the rest of the hamstrings, remained fully functional. Professor Paterson had made a series of observations upon the case, and he concluded that the long head of the biceps acted only until the limb had attained a position of semiflexion, the short head being then called on to complete the action.

(3) Mr A. R. THOMPSON read a short paper on "The Form of the Urinary Bladder." The paper was illustrated by several plaster casts made of

bladders shortly after death. The conclusions of the author's investigations were as follows:—

(1) The bladder is frequently asymmetrical.
(2) The bladders of individuals injected with the same quantity of plaster may vary very much from each other in shape and appearance.
(3) There is, in some cases, a well-marked bladder diverticulum on the side of the rectum. This diverticulum may be lateral or bilateral.
(4) The area and direction of the trigone vary in different bladders.

These anatomical conclusions are confirmed clinically by means of cystoscopic examination.

(4) Miss M. K. LANDER contributed a paper entitled "The Pectoralis Minor: a Morphological Study."

The primitive condition of the pectoralis minor is generally considered to be represented by a large muscular sheet inserting on the lateral surface of the shaft of the humerus. The insertion is assumed to show a phylogenetic migration cephalad over the capsule to the coracoid process, as in man.

But this supposed secondary attachment of the coracoid is also to be found in such lowly mammals as Tatusia and Galeopithecus, as well as in Phascolomys and other Metatheria. The coracoidal insertion is not a purely functional one related to a digging fore-limb, as it is not found in rabbits, badgers, or Mustelidæ. It is therefore probably correlated with skeletal modifications.

The coracoid process is primitively a large flat element between the sternum and the scapula. It subsequently dwindles in size to a mere tubercle above the glenoid cavity of the scapula. If a muscle originally attached to this process is forced to migrate owing to recession of the process, it may move (1) upwards over the acromion, (2) downwards over the capsule, or (3) inwards on to the clavicle. The pectoralis minor is found to have tried each of these directions: (1) in the Ungulates, (2) in the Carnivora and most rodents, and (3) in a few rodents, in which case the sterno-scapularis is also found, probably an attempt to retain the influence over the movable fore-limb. Insectivora and Primates, having fair-sized coracoids, show a variable insertion of the pectoralis minor muscle, but the tendency is toward the downward humeral insertion.

Ontogenetically the early attachment to the coracoid, with subsequent descent over the capsule to the humerus, may be traced in fœtal kittens, and muscular fibres are sent down to the coracoid in early rabbit and calf

embryos. Lewis describes caudad migration in the ontogeny of the human pectoral sheet.

In Monotremes there is no pectoralis minor, but rectus abdominis is inserted on to the coracoid process. In slightly less primitive mammals rectus is continuous, with a pectoralis minor going to the coracoid, save for the interposition of the lower costal margin or first rib. Humphrey has shown that the pectoralis major is merely rotated fibres of the superficial layer of rectus, and it is probable that pectoralis minor is a deeper layer rotated in a similar way owing to regression of the coracoid process laterally. In man connecting fibres between the insertion of rectus and the origin of pectoralis minor may frequently be demonstrated.

Pectoralis abdominis represents the lateral fibres of this upper part of rectus forced off the coracoid and down to the humerus, when the coracoid begins to diminish in size. Subclavius consists of the most mesial fibres forced back to the clavicle still earlier in myological history.

Anomalous arrangements of the deep pectoral sheet in man correspond to one of the three definitive conditions found in other animals. The size of the coracoid is very variable, and the pectoralis minor is in a condition of migration.

Professors THANE, FAWCETT, and KEITH discussed this paper.

(5) A paper by Professor AMIN ABDEL RAHMAN on "A Case of Complete Transposition of the Viscera" was, in the absence of the author, taken as read.

SUMMARY OF PROFESSOR FAWCETT'S COMMUNICATIONS ON THE DEVELOPING CHONDROCRANIUM.

Professor FAWCETT communicated, at the meetings held during 1914, 1915, 1916, the results of observations made on the developing chondrocrania of various mammals, and exhibited wax-plate models of them in illustration.

The models in question were:—mole, 19 mm.; nine-banded armadillo, 12 and 17 mm.; Australian native cat (*Dasyurus viv.*), 25 mm.; calf, 19 and 25 mm.; cat, 25 mm.; hedgehog, 25 mm.; water-rat, 25 mm.; ferret, 19 and 25 day. Many other stages of most of these animals had been examined in addition to those modelled, and he expressed his cordial thanks to the donors and loaners of the material, viz. Professors Wood Jones, J. P. Hill, and Arthur Robinson.

The results briefly summarised here will be published *in extenso* at a later date. Commencing with the basilar part of the chondrocranium, and first especially with those parts in the neighbourhood of the middle line,

there are to be recognised from behind forward the following parts:—first, a part developed under the notochord—a hypochordal part; next, a part through which dorso-ventrally and caudo-rostrally the notochord runs until it comes into contact with the epithelium of the dorsum of the pharynx—a parachordal part; next, a part developed independently of the two previous parts which surround the pituitary body—the trabecular part. (In the mole of 9–10 mm. separate procartilaginous and cartilaginous trabeculæ are quite evident. In *Tatusia* of 12 mm. a single trabecula is laid down like a ring around the pituitary body.) A cellullar gap at first separates the parachordo-hypochordal cartilage from the trabecula, which evidently corresponds with the like space in, say, the reptile. Next follows an independently chondrified interorbito-nasal septum. This is quite clear both in the mole of 9–10 mm. and in *Tatusia* even as late as the 17-mm. stage; but the trabecula (formed by union of two lateral trabeculæ in mole) ends at the ventral-hinder extremity of the interorbito-nasal septum, exactly as in *Lacerta*—the two, however, being distinctly separate.

These three elements of the median basal line, viz. the hypochordo-parachordal, the trabecular, and the interorbito-septal, at a later stage fuse together to form a continuous cartilaginous stem from the anterior edge of the foramen magnum to the anterior end of the nose, and in the following manner the hypochordo-parachordal segment ends anteriorly in two lateral points; these elongate in a forward direction, and unite with backwardly directed and similar processes of the trabecula.

(In *Tatusia* the whole of the plate which I have designated hypochordo-parachordal is hypochordal, and the trabecula shifts in a caudal direction over the front end of this plate, so burying the notochord.) The trabecula fuses anteriorly with the lower edge of the interorbito-nasal septum.

It is interesting to note that the basi-cranial axis, including the lower border of the interorbito-nasal septum in the Metatheria, in the Edentates, the Ruminants and Rodentia and Insectivora examined and modelled, is particularly flat from behind forwards in the well-chondrified state, whereas in the Carnivora and Man it is bent in such a way that the nasal capsule is almost at right angles to the rest of the median basilar region. The flattening out of the axis, which is secondary in the edentate and probably also in the insectivore, has the effect of pushing the trabecular region backwards over the dorsal surface of the parachordal plate and so burying the notochord.

Development of Paramedial Structures from behind forwards.—From the hypochordal part of the hypochordo-parachordal plate more particularly an outgrowth takes place which forms that part of the occipital cartilage which belongs more especially to the exoccipital region, and this

sends forwards under the auditory capsule a process which is identical with the jugular process of human anatomy. The twelfth nerve passes out through the occipital cartilage by either one or two foramina according to the species, and not infrequently species makes no difference. Anterior to the exoccipital region the auditory capsule is laid down, always chondrifying first around the semicircular canals, and finally around the cochlear duct. The manner of chondrification of the canalicular part of the capsule varies much with the species. In some, marked cartilaginous prominences are present on the surface, more particularly corresponding with the anterior and posterior semicircular canals, recalling the reptilian condition. In all cases a well-marked depression is found under the arch of the anterior semicircular canal—fossa subarcuata, or so-called floccular fossa. In no case save that of *Miniopterus* have I seen any flocculus lying in this fossa. The facial nerve always has a close relation to the division between cochlear and semicircular canal region, and a suprafacial commissure develops over the nerve, growing outwards from cochlea to vestibular and semicircular region over the nerve, as observed in the calf. In the mole an upwardly directed lamina of cartilage grows from the canalicular capsule to end freely—the operculum: this latter ossifies. In *Microtus amphibius* (water rat) the lateral aspect of the canalicular capsule in its upper half is hidden by the downgrowth of the tectum synoticum—of which later.

Anterior to the auditory capsule lies the ala temporalis, which in some marsupials is continued from the trabecula directly into the orbito-parietal commissure. In most it is laid down as an independent element in cartilage, which by its median end articulates for a time with the trabecula, and particularly in man at the 27-mm. stage the connection presents all the appearances presented by a developing diarthrodial joint. In the mole it seems to be chondrified in continuity with the trabecula. In *Tatusia* it is chondrified before the trabecula. In its relation to the branches of the fifth nerve it varies. The lower in the scale one goes, the more it tends to be associated with the mandibular division of that nerve, and not infrequently is perforated by it, *e.g.* calf. In ferret and man no immediate relation is presented to this nerve, but the ala is perforated by the maxillary division. In all cases it serves for the partial origin of the external pterygoid muscle. Anterior to the ala temporalis the ala orbitalis is met with. This is chondrified independently, and sends towards the hinder part of the interorbito-nasal septum one or two limbs: if one, that passes in front of the optic nerve; if two, then one passes anterior to the nerve, the other posterior to it. In the marsupial the posterior limb fails, so that the optic nerve passes through the same fissure as the other nerves of the orbit. The same condition is met with in *Microtus*. In *Tatusia* a

foramen is met with lateral to the optic foramen, through which a blood-vessel passes from orbit to lateral cranial vein. This foramen recalls and is possibly homologous with the epioptic foramen of *Lacerta*, in which case the hind limb of the ala orbitalis is a true metopic tænia, as in *Lacerta*. I have not met with this foramen in other species, but the early chondrocranium of *Tatusia* is so extraordinarily like that of *Lacerta* that its presence is not surprising. Developed in connection with the hinder limb of the ala orbitalis and below the optic nerve is a muscular process—the so-called ala hypochiasmata. Naturally, where this hind limb fails the ala hypochiasmata likewise fails. It serves for the early attachment of the rectus system of muscles, especially the medial rectus of the eyeball. In the mole, where the eye muscles and eyeball are in a very rudimentary condition, the ala is wanting or extremely small. In *Tatusia* it seems to chondrify independently. In the hedgehog the margin of the optic foramen is almost tubular, and the eye muscles of the rectus system arise from this tube.

Anterior to the alæ orbitales is the nasal capsule. This in all the chondrocrania examined was divisible into three parts, viz. an anterior (Sakterwulst) or vestibulo atriæ; a middle part which might be called fronto-maxillary; and a posterior, the cupolar or ethmoidal part.

The anterior segment is separated from the middle one by a groove on the exterior—the antero-lateral sulcus, and a corresponding ridge in the interior—the crista semicircularis. The middle segment (fronto-maxillary) is separated from the posterior one by a sulcus on the exterior—the postero-lateral sulcus, which corresponds with a prominent ridge internally—the first ethmo-turbinal. This arrangement is constant throughout the series examined. In the fronto-maxillary segment two or three antero-posterior turbinals are formed, low in height. In the posterior segment three main turbinals project one behind another into the cavity of the nose, of which the most anterior, the first, is the first to develop and the others follow in succession; the first ethmo-turbinal tends to split into two somewhat divergent lamellæ. Between these main or primary ethmo-turbinals secondary ones are developed later and are much lower in height. The roof of the nasal capsule, divisible into two parts, viz. a hinder or subcerebral, and a more anterior, is only complete in its pre-cerebral part. The subcerebral part, until the formation of a cribriform plate, shows a large vacuity, opening more particularly into the hinder or cupolar segment and into the fronto-maxillary segment; and when the cribriform plate is later formed it is divided by an oblique stem of cartilage—the cribro-ethmoidal crest—into an antero-lateral group of foramina communicating in particular with the fronto-maxillary segment of the nose, and a postero-median part

communicating with the cupolar or ethmoidal segment. At the anterior end of the cribro-ethmoidal crest a foramen, the foramen epiphaniale, runs through the capsule to the exterior for a short distance for the lateral branch of the nasal nerve.

In *Dasyurus*, in the mole and hedgehog and water-rat there is a well-marked flattened roof to the cupolar segment of the nasal capsule behind the cribriform plate. This is not met with in the remainder of the series. The floor of the nasal capsule exhibits varying degrees of completeness, according to age and species. In all there is formed anteriorly a lamina transversalis anterior. This may be almost horizontal or nearly vertical. In all save ferret and man it is prolonged backwards along the septum for a varying distance as the anterior paraseptal cartilage. Similarly, posteriorly, in the floor of the nose a lamina transversalis posterior is developed sooner or later, even in man. And this lamina transversalis posterior becomes connected by a narrow median piece along the septum, the posterior paraseptal cartilage with the anterior paraseptal cartilage, the junctional region being very narrow. The result is a complete common paraseptal cartilage, such as is seen in *Dasyurus viv.*, in the rabbit, in *Microtus*, and others, but this connection may not be brought about when, as in *Tatusia*, the mole, calf, ferret, hedgehog, and man, anterior and posterior paraseptal cartilages remain separate although connected with one another by fibrous tissue.

That the posterior paraseptal cartilage and lamina transversalis posterior are derived by thrusting back of the posterior wall of the nasal capsule, and at the same time the incurving and atrophy of the lower part of the median wall of the capsule, is evident and strikingly shown in specimens of progressive age of *Dasyurus*.

In the ferret and man the anterior paraseptal cartilage has lost its connection with the lamina transversalis anterior, and in the latter bears no immediate relation to the organ of Jacobson.

In man the lamina transversalis anterior is not formed, for the most part, only its median segment remaining as the processus lateralis ventralis. At no time are either common paraseptal cartilage, or its component parts, the anterior and posterior paraseptal cartilages, in cartilaginous continuity with the septum nasi.

The gap in the floor of the nasal capsule corresponding with the posterior choana is bounded in front by the lamina transversalis anterior, when that exists, by the lamina transversalis posterior posteriorly, by the lateral wall of the nasal capsule laterally, and medially by the common paraseptal cartilage or its representatives.

Anteriorly, in front of the lamina transversalis anterior a fenestra

narina exists. This may be placed, as in the majority of cases, anteriorly, but in a few, such as *Dasyurus*, it is laterally placed, and a distinct cupola anterior is found at the anterior end of the nose. In man the fenestra narina and the choana communicate, owing to the lack of a lamina transversalis anterior, and a long rostro-ventral fissure is the result.

The nasal septum is the forward continuation of the interorbital septum. In the rabbit and in *Microtus* it shows a perforation in the cartilage or septal foramen. This is not far from the anterior end, and it recalls that of *Reptilia*. The whole form of the nasal capsule bears out the suggestion that it has been thrust back along the interorbital septum by the increase in size of the epithelial nasal sacs, and that its medio-inferior wall has remained only as the common paraseptal cartilage or its representatives in cartilage or fibrous tissue.

Lateral Structures in the Neural Part of the Chondrocranium.—Posteriorly at the most lateral extremity of the exoccipital cartilages on each side there is laid down a supra-occipital cartilage. This rapidly grows towards its fellow in the middle line, as seen in the calf. Later it sends forwards a process which connects it either directly with the canalicular part of the auditory capsule or with the orbito-parietal commissure (of which later). A gap is formed thus between the canalicular part of the auditory capsule and the supra-occipital cartilage, which has received various names. When fusion has taken place between the supra-occipital cartilages with one another in the mid-dorsal line, and anteriorly on each side with the canalicular part of the auditory capsule, the so-called tectum synoticum is formed. Its mode of formation is best illustrated by the calf and hedgehog. It would appear that it reaches its highest development in man, and in man a second tectum synoticum is formed anterior to the main one, but independently of it, and very much smaller. In man from the 30-mm. stage a well-marked processus ascendens grows forwards from the tectum posterius in the middle line, recalling the condition in *Lacerta*.

Antero-lateral to the tectum synoticum arises in the lateral membranous wall of the chondrocranium a plate of cartilage, the parietal plate, but whether by independent chondrification or by upgrowth from the canalicular part of the auditory capsule, the specimens examined do not show. But in all cases above quoted, save in man, this plate becomes connected sooner or later with the postero-lateral extremity of the ala orbitalis, and an orbito-parietal commissure results stretching from the ala orbitalis to the canalicular part of the auditory capsule. Small foramina for vessels create vacuities in this structure.

Anterior to the fusion of the ala orbitalis, the antero-lateral angle of the

last-named cartilage grows forward to a process which has grown backward from the frontal part of the fronto-maxillary segment of the nasal capsule, and when fusion takes place a spheno-ethmoidal commissure is the result. The two stages are shown in the 19- and 25-mm. stages of calf. In the sheep, as is well known, the spheno-ethmoidal commissure is not complete.

With the formation of a spheno-ethmoidal commissure, an orbito-parietal commissure and a tectum synoticum, a complete lateral and posterior and at the same time somewhat ring-like cartilaginous wall is formed for the neural part of the chondrocranium.

Between the orbito-parietal commissure and the median structure, especially the trabecular region, a large gap is left which is partially broken up into two by the projection into it from the trabecular region of the ala temporalis. It is entirely divided into an anterior and posterior part in those marsupials in which the ala temporalis fuses laterally with the orbito-parietal commissure. That part behind the ala temporalis and over its outer extremity is filled with fibrous tissue, in which later the alisphenoid and squamosal are largely developed. The vacuity in front of the ala temporalis becomes to a great extent the sphenoidal fissure. The gap between the ala orbitalis and the nasal capsule, bounded laterally by the spheno-ethmoidal commissure, is the orbito-nasal fissure, and transmits the nasal nerve to the upper surface of the cribriform plate, and will ultimately be reduced to form the anterior ethmoidal canal.

Connections of the Median Structures with the Paramedian Ones.—The hypochordo-parachordal region becomes twice connected with the auditory capsule, first by exoccipital fusing with the canalicular part of the capsule to form the jugular process; secondly, with the cochlea, to form a parachordo-cochlear commissure. This is clearly seen in the mole and in the cat.

The trabecular region is doubly connected with the cochlear region once medial to the internal carotid artery and once lateral to it. The lateral connection, the so-called ali-cochlear commissure, clearly belongs to the trabecula, as is shown in *Tatusia*. Between the hinder trabeculo-cochlear commissure and the parachordo-cochlear commissure a basicochlear fissure remains permanently in the chondocranium of the mole and cat; but if such exist in the others examined, it must have been obliterated at a very early stage, for in none of them examined is such a basicochlear fenestra present, but a continuous fusion exists along the median aspect of the cochlear with the median structures. In the nine-banded armadillo a basicochlear fissure or fenestra exists first, but it closes up as development proceeds.

In man at the 27-mm. stage my specimens show that the so-called ali-cochlear commissure (anterior trabeculo-cochlear commissure) is in direct continuity with the cochlea lateral to the internal carotid artery, so the resemblance to the mole, cat, and other animals is here quite complete. This continuity may be—and, so far as I know, is—given up later, and the anterior trabeculo-cochlear commissure chrondifies independently in man, but this may be regarded as a secondary condition and of no morphological value. No sufficient reason seems to support the view that the mode of entrance of the internal carotid artery to the skull is different from that in the *Reptilia*; in fact, the conditions described seem to harmonise the two.

Visceral Skeleton.—Nothing of importance was noted at variance with the now usually accepted views as to its formation so far as concerns the first arch. In the second arch much the same may be said; the stapes was perforated by the stapedial artery in all save *Dasyurus*, and in the young *Tatusia* distinct evidence was obtained of the medio-hyal and latero-hyal divisions of the posterior end of the hyoid arch, the latero-hyal in the usual manner being fixed at the lower end of the tegmen tympani (crista parotica). In some it was unchondrified, in others chondrified.

The third arch was in all cases of comparatively small size, and clearly formed the so-called greater cornu of the hyoid; it was usually connected with the posterior end of the next or fourth arch by a cartilaginous bridge.

The fourth arch in all formed the thyroid cartilage from *Dasyurus* onwards, deepening as the animal rose in the scale; the foramen in the side of the thyroid cartilage, sometimes looked upon as an indication of its formation from the fusion of fourth and fifth arches, being merely produced by folding over of the hinder part of the fourth arch to meet the more anterior part, as shown in the two *Tatusia* models. The fifth arch in all cases formed the cricoid cartilage. In *Dasyurus* the upper end of the trachea was so formed as almost to simulate a sixth arch, but in this as in all other cases the position of the arytenoid cartilages stamped the cricoid or fifth arch, if anything else were indeed required. From Metatheria onwards, then, the thyroid cartilage was formed from the fourth arch, and that alone.

Accessory Cartilages in the Chondrocranium.—These are cartilages which develop in certain bones without any connection with the primordial chondrocranium. They were found in connection with the mandible, usually in the condylar and angular regions, but in *Microtus* a pair existed near the anterior end of the mandible on its medial side and close to, but not in any way connected with, the corresponding Meckel's cartilage; and

in addition another was found at the hinder end of what is often but erroneously designated splenial. This has not been observed in any other animal examined. The one near the anterior end recalled the symphysial cartilage found in man. In connection with the maxilla and with the palate bone at the medial edge of the palatine process, it seemed to be the usual thing to find an accessory strip of cartilage, but this was absent from *Microtus*, and is not present in man; but in man a cartilage appears in the outer alveolar wall and root of the malar process of this bone which was not elsewhere observed. In *Microtus* an accessory cartilage appears at the hinder end of the post-auditory process of the squamosal, and in the 35-day ferret the lower edge of the squamosal also develops such a cartilage.

The cartilage forming the hamulus or its representative for the pterygoid bone was found in all save *Dasyurus*, and in all was accompanied by such bone, save in the mole.

The above is a condensed, brief, and perhaps, without illustration, almost unintelligible account of the results of the researches carried out. It does not contain any references to work previously done, all of which will appear when the various chondrocrania are described *in extenso*, but the more important points which it seems to settle are the establishment of the existence of separate trabeculæ and interorbito-nasal septum, the presence of a hypochordal segment too of the basilar part of the chondrocranium, the mode of formation of the various commissures, a more concise account of the manner of formation of the nasal region, and especially of the paraseptal cartilages, the significance of the ala hypochiasmata, and, with reference to the visceral skeleton, the origin of the thyroid cartilage. Finally, new accessory cartilages are introduced.

Many interesting points were also brought out with reference to the mode of origin of the covering bones of the chondocranium, but these will be dealt with later.

Professor Fawcett expressed his indebtedness to the following students, without whose help he could not possibly have attempted to make the numerous models which illustrated these communications:—Miss Salter, Miss Casson, Miss Richmond, Miss Neville, Miss Brown, Miss Llewellyn, Mr R. P. White, Mr G. E. Pilsley, and Mr Datta.

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PREFACE TO THE FIFTY-FIRST VOLUME

THE issue of the first part of this volume of the JOURNAL OF ANATOMY AND PHYSIOLOGY coincides with a change in the management and control of the Journal. In future it will be named the JOURNAL OF ANATOMY, and will be the official organ of the Anatomical Society of Great Britain and Ireland, whose property it now is.

It must, however, be clearly understood that the change of proprietorship does not involve any departure from the policy hitherto followed of accepting for publication in the pages of the Journal approved articles other than those read before the Anatomical Society.

The Journal was founded by the late Sir William Turner in 1866. In a preface which he contributed to the fortieth volume he gives his reasons for establishing the Journal, and mentions the changes which had occurred in its editorial staff up to that year. He also acknowledges the active part taken in the arrangements for the institution of the Journal by the late Sir George Murray Humphry, "who undertook for some years the duty of acting editor."

"On the completion of Volume XX. in 1887 a new series was commenced, with Professor Turner as acting editor." Although in later years others were responsible for the editorial work, "he retained to the end his interest in the Journal, and every sheet of each issue passed through his hands before going to the press." He died on the 15th of February of the present year: had he lived a few months longer he would have had the satisfaction of seeing the completion of the jubilee volume.

In 1906 Professors A. Macalister and D. J. Cunningham undertook the management of the Journal, and Macalister edited three volumes (XXXII. to XXXIV. inclusive). Cunningham followed with the next seven volumes (XXXV. to XLI. inclusive), and "under his auspices an important change in the size and appearance of the Journal was made in 1905 in the fortieth volume." Macalister resumed the duties of acting editor in 1908, and since that year has edited nine volumes (XLII. to L. inclusive). He has spared

neither time nor trouble to improve the Journal and enhance its scientific value.

Professors A. Thomson and A. Keith joined the editorial staff in 1907, and Professor A. Robinson in 1909.

Until the year 1878 the Journal was the organ of the two sciences, Anatomy and Physiology. In that year the *Journal of Physiology* was established, and thereafter "physiological" papers became few and far between in this Journal, and finally ceased to appear. It has therefore been deemed advisable to drop the words "and Physiology" from its title.

ROBERT HOWDEN,
President of the Anatomical Society of Great Britain and Ireland.

October 1916.

JOURNAL OF ANATOMY

THE SHAPE AND PERITONEAL RELATIONSHIPS OF THE SPLEEN IN MONOTREMES AND MARSUPIALS.

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IN the course of investigations on the comparative anatomy of Monotremes and Marsupials, which I have been conducting during the past six years, and which at first had special reference to the evolution of muscular action, my attention was arrested by certain peculiar features of the spleen, both as regards its shape and relationships, which throw light on the anatomy of the human spleen. A search through available literature relating to the two orders showed little reference to the subject, apart from the description originally given by Richard Owen. On account of the large amount of material I have had for dissection—the Monotremes alone numbering fifty specimens—individual variations have been excluded. In this monograph I propose to give first a general description of the spleen and its relations in the two orders, and, secondly, to offer an explanation of the apparent differences and their bearing on the shape and relationship of the human spleen.

THE SPLEEN IN MONOTREMES.

Platypus (*Ornithorhynchus anatinus*).

On opening the abdomen of the Platypus, concomitant with the presence of a diaphragm and great omentum one is struck by the large development of the spleen and pancreatic tissue, and the right stem of the former may extend from the left hypochondrium to the right iliac region.

The spleen (fig. 1) is somewhat V-shaped, and three portions are recognised, viz. a small body 2·5 to 3 cm. long directed towards the œsophagus and in the great omentum (lesser sac); a large right ventral (anterior) process lying freely in the abdominal cavity and suspended also in the great omentum, 12 to 15·5 cm. long, with the width varying from

2 to 2·5 cm. and thickness 1·5 cm.; and a shorter left dorsal (posterior) process 7 to 9 cm. long, with a width of 1·75 to 2 cm. and thickness of nearly 1 cm. This left process is outside the lesser sac in relation with a fold—the left lateral or lieno-mesocolic—connecting it to the mesocolon of the left or distal colon. The distal colon is never fixed dorsally, and the average maximum width of the mesocolon equals 5 cm. The pancreas is found diffusing itself on the left aspect of the mesocolon in relation with the left lateral fold. The fold with the left splenic process and pancreas can be lifted free from the ventrum of the left kidney and the dorsal wall.

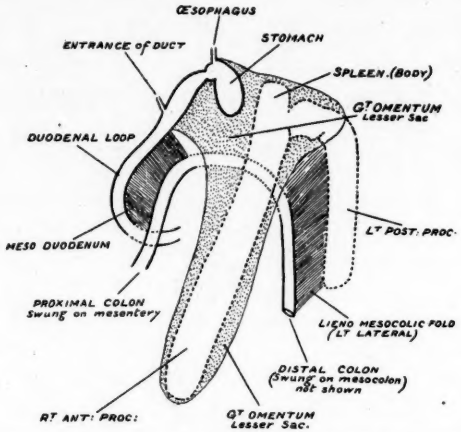

FIG. 1.—The peritoneal relations of the spleen in Platypus.

Whilst the right process and body of the spleen are continuous, the left process is arched and forms practically a right angle with the body. A deep notch is present at the cephalic margin between the two, and the actual width of attachment may be less than 2 cm. One or two small notches may be noted at the caudal border near the termination of the lesser process, and a notch directed towards the body between the right and left processes. It is interesting to note that in an Agama (Reptilia) measuring 30 cm. snout to vent and abdominal width of 7 cm. the spleen was 1·5 cm. long and ·4 cm. wide, while the snout to vent measurement of the Platypus is 37 cm. and width 13 cm.

Echidna (*Echidna aculeata*).

As in the Platypus, three main portions of the spleen may be recognised (fig. 2), viz. body and two processes; but while uniformity is characteristic

of the spleen of the Platypus, although conforming to the general character it is rare in the Echidna to find two spleens alike.

(1) Body.—This is better defined than in Platypus and is in relation to the stomach fundus, being directed towards the œsophagus. It is suspended in the great omentum, the width of which, even in a male adult, only equals 1 cm.; and so at this early stage we obtain the definition of a gastro-splenic omentum. Its length varies from 3 to 5 cm. and the width ·5 to 1 cm.

(2) The right ventral process is the longer of the two and is also suspended in the great omentum (lesser sac), the width of which at its anterior

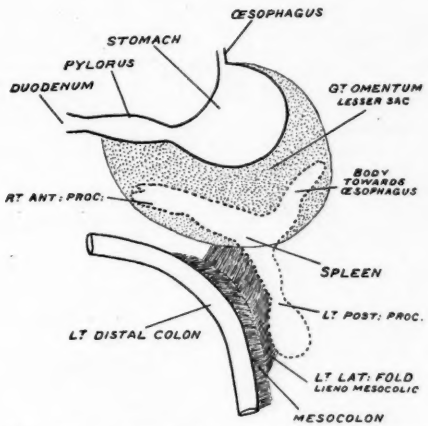

FIG. 2.—The peritoneal relations of the spleen in Echidna.

extremity is 7 cm.; so that it is more mobile than the body. Its average length is 5 to 7 cm. and width ·5 to 1·5 cm.

(3) Left dorsal process.—This is shorter than the anterior, and two portions may be recognised, viz. a stem terminating in a pear-shaped body, which may be smooth or (especially in smaller specimens) corrugated. The stem rarely runs directly into this portion. Usually there is narrowing at the point of attachment, and the connection between the two may be merely a slender fibrous thread. The stem varies from 1·5 to 3 cm. in length and average width ·5 cm., while the body varies from 2 to 3·5 cm. in length and circumference may reach 5 to 6 cm. This process, as in Platypus, lies outside the lesser sac in relation to the lieno-mesocolic fold, extending caudally towards the pelvis on the left of the distal colon. In one specimen out of a large number examined, I found the left stem included in the lesser sac. The distance between the pear-shaped body and colon may only equal

·75 cm. The pancreas is a less mobile organ than that of the Platypus, and in not one of the numerous specimens examined by me did it extend sinistral to the lesser sac, so as to come into relation with the lieno-mesocolic fold. The distal left colon is mobile, having a mesocolon. In one specimen this was greatly narrowed and the length of the distal colon in the abdomen only equalled 7 cm. In another—a male specimen—the pancreas was a "fixed" organ and on the right side was adherent to the lobus caudatus. The left or distal colon was fixed dorsally, describing an almost vertical course to the pelvis. In close relation in this specimen, and all fixed dorsally in the left lumbar region, were the left testis, kidney, pear-shaped process of spleen, and distal colon. The pancreas extended but a short distance on the left of the colon and apparently had little influence in the fixation of this structure, since it never extended to the left in relation with the lieno-mesocolic fold. Yet fixation has occurred. In this specimen, as well as the one with a shortened mesocolon, the distal left colon was relatively short; there was a failure to develop, with atrophy of the mesocolon. Instead of the distal colon from the duodeno-intestinal flexure to vestibule being 28 cm. long—the average adult male length—it only measured 13 cm.

The Spleen in Marsupials.

In this order we meet not only with types of spleen presenting the early mammalian character seen in the Monotremes, but with types becoming dorsally fixed and resembling closely the human spleen.

Tasmanian Devil (*Dasyurus sarcophilus*).

In this Marsupial there is a well-defined great omentum extending from the pyloric region to the left along the great curve of the stomach. No duodenal loop is present, and no well-marked distinction between colon and small intestine as in other Marsupials. The intestinal tract is reptilian in character, consisting of a canal 157 cm. from pylorus to pelvis, swung apparently on a single mesentery 7 cm. long at its dorsal attachment. This latter consists of two portions—an upper 1·5 cm. long (superior mesenteric) and corresponding to the duodenum and small gut (135 cm.), and a lower (5 cm.) representing the original mesocolon and corresponding to the remaining 22 cm. of intestine, which is large gut.

As in Macropus, the spleen presents three distinct portions:—

(1) A large portion or body directed along the great curvature of the stomach towards the œsophagus. It is swung on the great omentum, which is 2 cm. wide at the left extremity and 10 cm. at the right. At the left extremity, in addition to the shortened omentum (gastro-splenic), a

peritoneal band stretches across the omentum between the stomach and spleen. The body varies from 7 to 8 cm. in length, and greatest width is 1·75 cm.

(2) The right ventral process is also in relation with the lesser sac, being swung freely on the great omentum. It varies from 4 to 5 cm. long and is about 1·75 cm. wide. This portion forms almost a right angle with the body.

(3) The left dorsal process, 2·5 cm. long and 2 cm. wide, is outside the

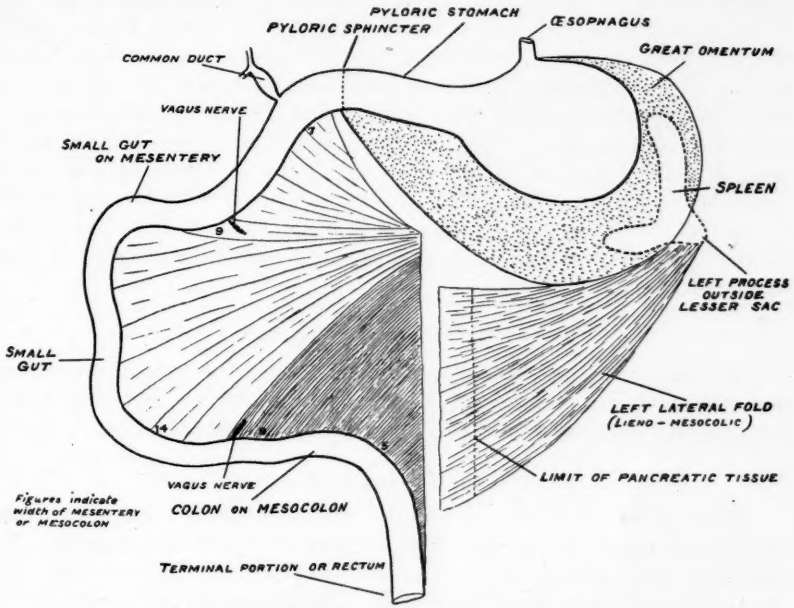

FIG. 3.—The gastro-intestine and spleen in Tasmanian Devil.

lesser sac and gives attachment to the left lateral fold. This membrane is somewhat triangular in shape and measures 9 to 10 cm. long, and over it the main pancreatic tissue diffuses itself, but it never extends nearer than 2 cm. to the dorsal attachment. The basal portion of the membrane (5 to 6 cm. long) extends from the root of the mesentery out along the lower part of the lesser sac to the left dorsal process of the spleen. Its left margin is free. The right margin is not continuous dorsally with the mesocolon of the large intestine, but with the peritoneum slightly to its left. The left lateral fold, as in the Platypus and Kangaroo, is free from dorsal wall and ventrum of the left kidney.

Koala (Phascolarctus cinereus).

The spleen is suspended in the great omentum, being contained in the lesser sac, and is characterised by the relative shortness of the left dorsal process and the absence (this being the only instance among Marsupials and Monotremes) of the left lateral or lieno-mesocolic fold. The shape of the spleen varies slightly in different animals. In all there is an elongated right ventral process varying from 7 cm. to 12·5 cm. long. It is usually constricted and fissured where it joins the main splenic mass. The remainder of the spleen or body may approach somewhat in shape the human type, forming

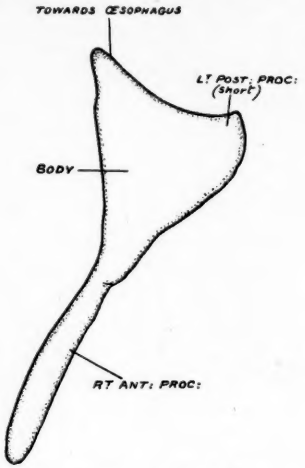

FIG. 4.—The spleen in Koala.

a triangular body 7 cm. long and 4 cm. across, with two small projections, one directed towards the œsophagus and the other representing the left dorsal process. The right process is much more mobile than the body, and while the width of great omentum between the left extremity and great curve of stomach equals 2·5 cm., at the right extremity this equals 9 to 10 cm. In some specimens the body is not relatively so large, and in place of the projections two processes are seen, separated by a well-defined interval or gap.

Macropodidæ (Kangaroos and Wallabies).

The spleen consists of three portions: (1) left, largest portion or body; (2) narrow elongate or right process; (3) wider, though shorter, dorsal left process.

The body varies from 11 to 15 cm. in length, with a maximum width of 4·5 cm. The short left process is 6 cm., with a maximum width of 3 cm.; and the right process 9·5 cm. long, and maximum width 1·75 cm.

Frequently the width of this process may only equal 1 cm., with a narrow attachment to the body—the connection being fibrous, with a sprinkling of splenic tissue. Such a process is one apparently undergoing a retrogressive evolution, and is found both in the Wallaby and Kangaroo. In the

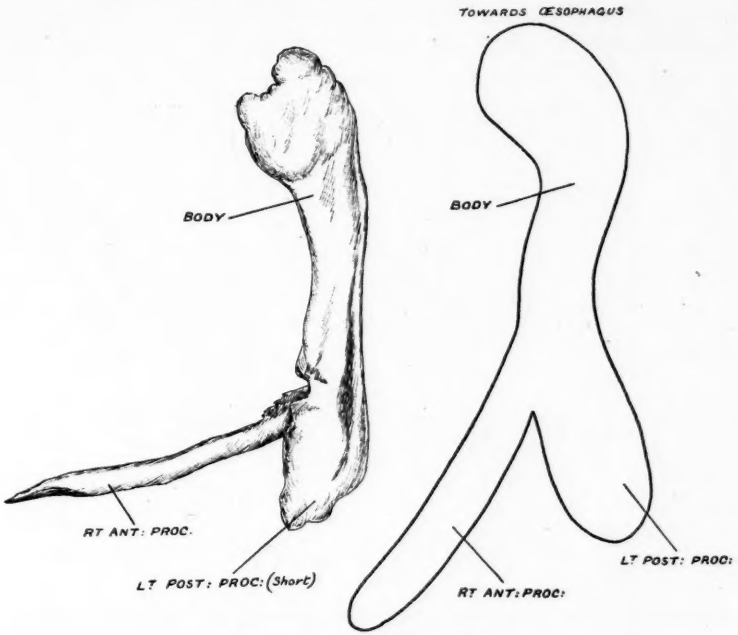

FIG. 5.—Spleens of Macropodidæ.

Tasmanian Wallaby I found the anterior process to be not only narrower but shorter than the left process. The great stomach in Macropus is a V-shaped organ with a large left and a smaller right limb, and the well-defined Spigelian lobe of the liver depending between the two. The body and elongated right process are suspended on the great omentum (lesser sac), being related to the greater curvature of the left limb as far to the right as the bend in the stomach. The process is less closely attached than the body. The short, wide left dorsal process is outside the lesser sac, being connected to the mesocolon of the distal colon by the triangular fold, the left lateral

or lieno-mesocolic, which is more developed in some specimens than in others. It is free from the dorsal wall and ventrum of the left kidney. Both as regards its shape and the disposition of the left lateral fold, the spleen of the Macropod presents the primitive Mammalian type, and resembles closely that of the Monotreme.

Opossum (Trichosurus—Pseudochirus).

In Trichosurus a marked advance towards the human type of spleen is to be noted, and light is thrown on the formation of the lieno-renal ligament

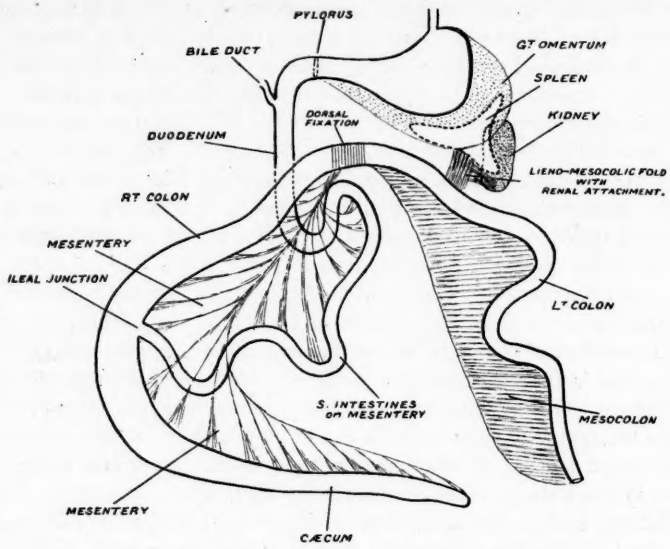

FIG. 6.—The gastro-intestine and spleen in Trichosurus.

and the mode of fixation of the distal colon and spleen. Although three portions of the spleen are noted, viz. body, right and short left processes, the organ is more compact and the processes less defined than in the preceding mammals (fig. 9). The body is directed towards the œsophagus and is suspended—like the right ventral process, which is directed along the great curvature of the stomach—on the great omentum, *i.e.* lesser sac.

The width of the great omentum (gastro-splenic) at the extremity of the body is 1·5 cm., and at the extremity of the right process the width is 5·5 cm., so that the narrowing gastro-splenic omentum is here well defined. The short left dorsal process is outside the lesser sac in relation with the

left lateral fold. Its average length is only 1·5 to 2 cm. The total average length of the spleen is 7 cm. and the width 1·5 to 2 cm. In addition to the outer or left and inner visceral or right surfaces, three margins can be defined, viz. renal or dorsal margin formed by the body and left process; right ventral margin formed by the body and right process; and left colic margin formed by the left dorsal and right anterior processes. On examining the inner or visceral surface (fig. 9) of the spleen we are struck with the resemblance borne to that of Man and the Wombat. We note a well-defined renal surface, concave, formed by the body and left process; a gastric surface formed by the body and right process, with the gastro-splenic omentum (great omentum) attached along a groove extending from the extremity of the body to the extremity of the anterior process. This surface is separated dorsally by a distinct raised edge from the renal surface, but unless there is a defined concavity this is not marked. From the gastro-splenic omentum, running down the left dorsal process, we see the attachment of the left lateral fold (lieno-mesocolic). This, with the anterior part of the gastro-splenic omentum, separates off the lower left or colic surface. Below the attachment of these two membranes we have a ridge simply the result of the impressions of the colon and stomach, just as the posterior ridge separating the renal from the gastric surface is the result of the renal impression. The lieno-mesocolic (left lateral fold), instead of being free as in the preceding specimens from the short left splenic process to the mesocolon of the distal colon, has, in addition, become attached to the ventrum and outer surface of the lower half of the left kidney. The result is that the spleen and left portion of the pancreas which is supported on the fold are brought into relation with the kidney, and so we have defined the concave renal surface of the spleen related to the upper and outer convex portion of the kidney—the pancreas lying ventral to that organ. Thus we see that we have a definitely formed lieno-renal fold which is really the upper part of the lieno-mesocolic fold, and the lower part of the fold is really now reno-mesocolic. A peritoneal band is noted in both Trichosurus and Pseudochirus from the middle of the convex border of the kidney to the lateral abdominal wall, and continuous over the kidney with the lieno-mesocolic fold. The attachment of the lieno-mesocolic fold to the left kidney (zygosis) is thus a factor in bringing the spleen into close relation with that organ, and this is more marked in some specimens than in others. In two specimens the pancreas lay ventral to the left kidney, and the renal surface of the spleen was related to the outer part; but all could be raised off the kidney, as they were suspended on the lieno-mesocolic fold, and this was not attached to the ventrum of the kidney as above described. The fold, however, was really lieno-renal, as its lower attachment was to the

dorsal wall at the lower pole of the kidney, *i.e.* it did not extend to the mesocolon, the lower portion being atrophied. In a smaller variety of Australian Opossum (Pseudochirus), though the spleen is practically similar to that of Trichosurus, the fixation of structures in the left hypochondrium and lumbar regions is more pronounced. The renal surface of the spleen is in relation with the upper and outer convex surface of the kidney, and the left process of the spleen can be raised slightly off that organ. The pancreas, however, is seen to be in close relationship with the ventral and outer surface of the kidney. In Trichosurus the left distal colon and mesocolon are free of lesser sac, but in Pseudochirus they are included for about 8 cm. This inclusion must be an important factor in approximating colon to spleen, although in Pseudochirus it is associated with a large process of pancreatic tissue in the lesser sac and free from the dorsum. Whilst in Trichosurus the colon and mesocolon are not brought close to the kidney, in Pseudochirus the lieno-mesocolic fold is relatively shortened up and the mesocolon is brought in direct relation with the caudal pole of the kidney, so that we find in close connection pancreas, left process of spleen, kidney, and mesocolon, only the shortened remains of the lieno-mesocolic fold intervening. In these two varieties of Opossum important light is thrown on the combination of correlated factors necessary to produce the close relationship of spleen, pancreas, and colon in the left human hypochondrium.

Wombat (Phascolomys).

The spleen is placed in the left hypochondrium in relation with the left part of the stomach and upper portion of the left kidney. It may be described as triangular in shape, presenting three margins: (1) dorsal or renal; (2) right, gastric, or ventral; (3) left, lower, or colic.

We also note three extremities or angles, viz. œsophageal or upper, right ventral, and a left extremity. In addition, two main surfaces, viz. outer or left, and inner visceral or right. Its greatest length is 12 cm. and breadth 11 cm.

Extremities.—(*a*) The œsophageal or superior extremity is most dorsal and frequently the most pointed, and lies 3 to 4 cm. from the œsophagus. It is in relation with the great curvature of the stomach, to which it is connected by gastro-splenic omentum, *i.e.* upper part of the great omentum, and which is thickened in this region, with a width of only 1 cm. Frequently, as in the human, it bends towards the inner surface so as to give a rounded shape to the upper end of the spleen. This is probably an accommodation effect for a well-developed left hepatic lobe, with the lower and inner part of which it is related.

(*b*) The ventral or right extremity is usually rounded and corresponds to the right ventral process seen in the Monotremes and other Marsupials. It is connected to the great curve of the stomach by the gastro-splenic (great) omentum, the width of which is 4 cm., so that it is more mobile than the superior angle. It is to be noted that the gastro-splenic omentum does not extend to the tip of either extremity.

(*c*) The left extremity corresponds to the left process seen in other

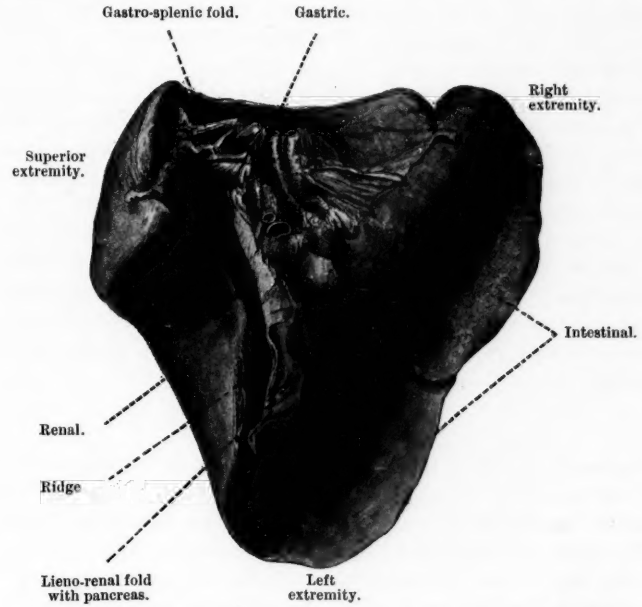

FIG. 7.—Inner or visceral surface of the spleen of Wombat (Phascolomys).

Marsupials and in the Monotremes, and is related to the outer margin of the left kidney about the middle.

Margins.—(*a*) Right (anterior of human) lies between the superior and anterior extremities along the great curve of the stomach. It is thin, usually concave, frequently notched below, and formed by the body and right ventral process.

(*b*) The left margin extends between the right ventral and the left extremities. It is usually thin, is the longest of the three, and presents a well-defined notch about its middle or towards the left, so that the left

process or extremity becomes differentiated off. It is free and comes into relation with the distal colon and the left portion of the stomach.

(*c*) The renal or dorsal margin extends between the superior and left extremities, being formed by the body and left posterior process. It is thicker and more dorsal than the others and is curved—being in relation with the outer convex margin of the left kidney.

Surfaces.—(*a*) The outer or left surface is usually smooth, slightly convex, corresponding to 8, 9, 10, 11, and 12 ribs. It is related to the diaphragm and the mesial or visceral surface of the left lobe of the liver.

(*b*) Inner right or visceral surface is more complex and presents, as in the human spleen, certain very definite areas, viz. right, gastric, or upper; left, lower, or colic; dorsal or renal. The attachment of the gastro-splenic omentum extends on the gastric surface close to the posterior boundary obliquely down and forward from within 1 cm. of the superior extremity to within 1 cm. of the tip of the right ventral extremity below. The lieno-mesocolic fold—which supports the left pancreas and the chief vessels—is attached on this aspect of the left process, and may or may not extend to the left angle or tip. Below it is attached to the ventrum of the caudal pole of the left kidney, so that it is lieno-renal. The left pancreas—unlike the human—can be raised from the front of the kidney. By means of this fold and the anterior part of the gastro-splenic omentum the lower or colic surface is defined. In addition, certain ridges are noticed on this aspect of the spleen. Along the attachments of the lieno-mesocolic and anterior parts of the gastro-splenic membranes is a blunt ridge, and following the curve of the upper part of the gastro-splenic membrane a slight ridge may be noticed. Dorsal to the upper part of the gastro-splenic membrane is a sharper ridge—renal ridge—the result of renal pressure, and separating off the renal and gastric surfaces. The renal ridge is traced along the left extremity, forming a prominence below.

(1) Gastric surface (right or upper) is somewhat triangular and concave for the fundus of the stomach. It corresponds to the body and right anterior process. Dorsally is the attachment of the gastro-splenic omentum with some small vessels, and below it is separated from the colic surface by the gastro-splenic membrane in front and the lieno-mesocolic behind. The pancreas, supported on the lieno-mesocolic fold, tends to encroach on the gastric surface between this fold, the renal ridge, and the gastro-splenic omentum. The dorsal limitation of this surface is the ridge behind the gastro-splenic omentum; or where the depression for the kidney is well marked a defined margin separates it from the renal surface.

(2) Left, lower, or colic surface.—This is separated from the gastric surface by the gastro-splenic omentum, and from the renal and gastric by

the lieno-mesocolic fold with pancreas, and more posteriorly the renal ridge, since the renal concavity extends to the left extremity. A well-defined fissure is seen a little below its middle, which, extending inwards, serves to define the left process. This surface corresponds to the right ventral and left dorsal processes of the Platypus, the notch on the edge leading to the fissure representing the original interval between the two. It is related to the distal colon, and when distended the stomach is seen to be related to the upper or ventral half (*i.e.* above the fissure), which portion is included in the gastric surface of the human.

(3) Dorsal or renal surface is the narrowest of all the surfaces and corresponds to the body and left posterior process. It is really a concavity for the upper part of the left kidney, and can be regarded as an accommodation effect. The concavity may extend almost along the whole length or be only limited to the lower four-fifths, since in cases with a well-developed left hepatic lobe the upper end of the spleen may be curved over towards the inner surface. The result of renal accommodation or pressure is to define on the inner and dorsal aspect of the spleen a ridge or margin—renal ridge—best defined below, where it forms a distinct projection or angle. This ridge separates the renal and gastric surfaces and, with the lieno-mesocolic fold, the renal from the colic below.

Interpretation of the Foregoing Facts.

A study of the spleen in these two orders throws light on the significance of shape of the human spleen[1] and on the correlations associated with its fixation in the left hypochondrium The spleen of the Wombat (Phascolomys) (fig. 7), though conforming more to the primitive Mammalian type, yet resembles the human so closely as to be at times almost indistinguishable, and so the so-called anterior, posterior, and superior angles of the human spleen become significant. These all have their prototypes in the Platypus. Two spleens are illustrated, taken at random from full-time fœtuses (fig. 9). As one might expect, the anterior process (*i.e.* ventral, right process of the Platypus) is well defined, while the posterior (*i.e.* dorsal, left process of the Platypus) is poorly defined. In both, fissures are seen defining the body from the processes. From the point of view of biology, *i.e.* function, the human spleen of the text-books cannot be accused of affording much information. Post-mortem examinations made for a period of six years with Dr S. Strachan at a benevolent home for the aged showed

[1] "The Notches and Fissures of the Spleen and their Meaning," F. G. Parsons, *Journ. of Anat. and Phys.*, vol. xxxv. pp. 416–427; "The Form of the Human Spleen," R. K. Shepherd, *Journ. of Anat. and Phys.*, vol. xxxvii. pp. 50–69.

me the great relative frequency of perigastric adhesions, perisplenitis, and old left pleuritis, all of which would profoundly modify shape. To throw light on the significance of shape it would be better if young subjects were chosen. One naturally wonders whether different portions of the Mammalian spleen have different functions. There is no biological evidence of this, nor can it be said to be borne out by histological examination, although important differences were noted in the spleen in the different members of the orders described. As regards the fixation of the human spleen, this, it must be borne in mind, is associated with fixation of the distal colon and left pancreas. The attempts made by nature can be studied in the Monotremes and Marsupials. In a study of the peritoneum of the members of these two orders, three primary folds are noted, which are traced in varying degree throughout the Mammalia, and play an important part in the fixation of the gut, which is coadjusted to the erect posture :—

(1) Mesial fold, approximating the colon to the pyloric region, and continuous in the Chameleon with the gastro-hepatic omentum or ventral mesogaster.

(2) Duodenal or right lateral, passing from the ascending duodenum to the right aspect of the mesocolon of the distal colon, which I regard as an acquired or physiological fold (zygosis).[1]

(3) Left lateral or lieno-mesocolic, from the left, dorsal, or posterior process of the spleen to the left aspect of the mesocolon of the distal colon. This, like the mesial, I regard as biological. The mesial fold is best defined in the Koala, the duodenal in Trichosurus, and the lieno-mesocolic fold in the Platypus. The origin of the left lateral or lieno-mesocolic fold was certainly very puzzling, and at first I was inclined to regard it as an acquired or physiological adhesion (zygosis) from a spleen which had wholly developed in relation to the lesser sac. A study of certain lizards supplied me, however, with a different explanation (fig. 8).

In Agama we notice the narrow splenic body in the mesogaster running parallel with the stomach. In Lygosoma (Scincidæ) the spleen was noticed passing almost vertically close to the dorsal wall and in relation not only with the mesogaster but with the mesentery and mesocolon as well. Correlated with the development of the Mammalian spleen we have the development of great omentum, and, in the case of the Agama, the enlargement would be wholly related to the lesser sac, as actually happens in Koala, in which the left process is insignificant; while in the case of Lygosoma an enlargement of the spleen would involve not only the mesogaster (great omentum, lesser sac) but the mesocolon as well. In Lygosoma the pancreas is noted as a single strand extending from the commencement of the

[1] "The Nature of Peritoneal Adhesions," Arthur Keith, *Lancet*, 8th August 1914.

duodenum to the lower portion of the spleen. Diffusibility is characteristic of its early Mammalian development. In the Platypus it diffuses itself on the right in the meso-duodenum and on the left on the lieno-mesocolic fold. Mesially it is fixed, forming the lower dorsal boundary of the lesser sac.

With development of the spleen is a correlated great omentum, but no inclusion primarily by the great omentum (lesser sac) of distal colon or pancreas. The pancreas as we ascend in the Mammalian scale becomes more compact. From the point of view of selection it would not be advantageous for it to be included in the lesser sac. It could not then conform to the abdominal law of dorsal fixation of solid bodies by which torsion especially of ducts is prevented in the erect posture. In addition, the dorsal fixation of duodenum, spleen, and left distal colon, of which its

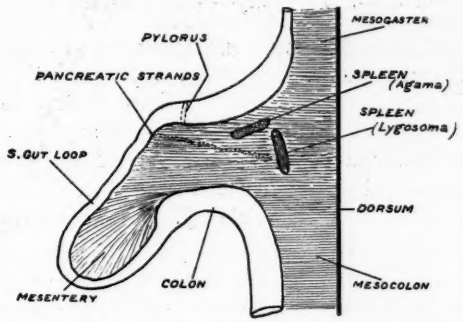

FIG. 8.—Diagram to show contrasted positions of spleen in Agama and Lygosoma.

own further dorsal fixation is an important factor, would be interfered with; and the significance of the relationship of the pancreas on the left to a fold (left lateral) connecting spleen and distal colon in the production of that arrangement becomes understood. This fold is completely absent in Koala, and in that Marsupial there is no fixation of distal colon, spleen, or left pancreas. Primary inclusion by the great omentum of the proximal 8 cm. of distal colon actually happens in Pseudochirus (Australian Opossum), and in this Marsupial, though distal colon, spleen, and kidney are proximal, there is a considerable amount of pancreatic tissue free in the lesser sac. Furthermore, a study of the Mammalia shows that for adaptability to a mixed diet selection requires not atrophy but development of the distal colon, which becomes ultimately fixed as in erect Man in the left hypochondrium. In the Echidna, whose diet is chiefly ants, a failure to develop or atrophy of the distal colon and mesocolon is correlated with the dorsal fixation of that gut and of the pancreas, but not of the spleen. I regard

that as the evolutionary tendency in the Echidna (since I have seen the various grades of shortening of the mesocolon), and nature does not retrace her steps. From the point of view of "selection" for the evolution of the human type, the arrangement in the Platypus is superior to that of the Echidna.

The "selection" factors would be:—

(*a*) Lieno-mesocolic fold lying ventral to left kidney, connecting spleen and mesocolon, and supporting pancreas.
(*b*) Pancreas outside the lesser sac.
(*c*) Shortening of the great omentum (gastro-splenic omentum) between the left extremity of the spleen and stomach fundus, with secondary peritoneal bands between the two.
(*d*) Development—not atrophy—of the distal colon.

As evolution proceeds, the pancreas, which even in the Platypus is fixed dorsally about the root of the mesentery, approaches the dorsum on the right and left sides (in the Echidna direct adhesions may be noted between pancreas and lobus caudatus), which means some approximation of spleen and mesocolon. Adhesions form between the lieno-mesocolic fold and ventrum of the left kidney as in Trichosurus—the fold ending in the Wombat at the lower pole of the kidney. Thus is developed the lieno-renal band. The development of the so-called human "intermediate" angle (which really represents the lower limitation of the renal ridge) is now easy to understand. Further evolution results in further atrophy or shortening of the lieno-renal (mesocolic) fold. The pancreas and colon become more closely related to the spleen, with an encroachment on the lower portion of the renal concavity and atrophy of the lower part of the renal ridge.

A new feature becomes added which can be effectively studied throughout the Primates, viz. the inclusion by great omentum first of the mesocolon and later of the distal colon—the pancreas now being a dorsal organ. This inclusion or fusion begins from right to left, and the importance of the mesial fold previously mentioned, between the colon and pyloric region, is seen. In a young Baboon (Catarrhina) (fig. 9), the "lieno-mesocolic" is simply a fold between the spleen and the upper part of the kidney, *i.e.* it is atrophying, and the ridge on the inner surface of the posterior angle or process has almost gone. The lower part of the renal and the colic surfaces are becoming continuous with the "intermediate" angle becoming evident. Here, however, the colon is not fixed, but the mesocolon at its commencement is partially applied to the great omentum. The colic surface is not, as in the human spleen, encroached on by the stomach, *i.e* the relationship of

colon to spleen is not limited as in the human, and the gastro-splenic omentum goes almost to the tip of the anterior process. In a young Orang Utang, however (fig. 9), the colon is fixed dorsally. It is included (secondarily) in the lesser sac by the great omentum, and has only a limited relation to the spleen. The anterior portion of the colic surface is en-

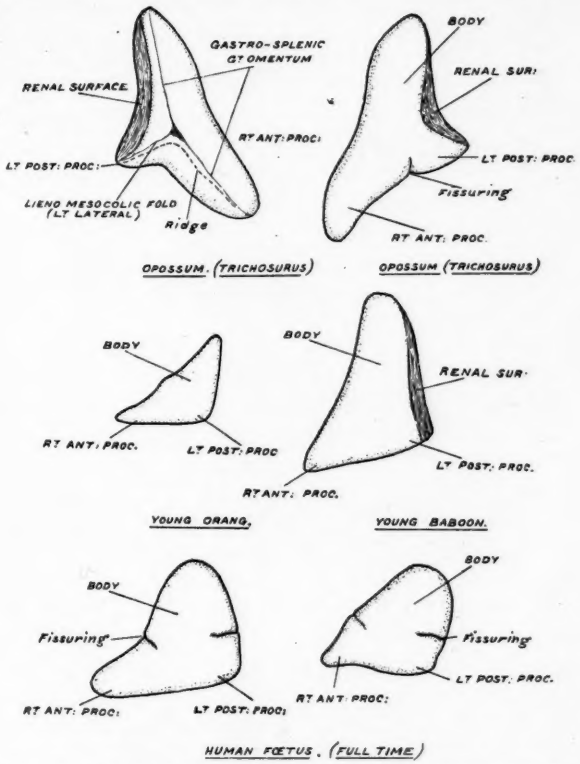

FIG. 9.—Spleens of Opossum, Orang, Baboon, and human fœtuses.

croached on by the stomach as in the human spleen. Thus, with its fixation the colon comes into relation with a limited area of spleen only, though previously related to the whole colic surface. As to whether the stomach will encroach on the colic surface depends on the atrophy of the right or anterior part of the gastro-splenic omentum. With dorsal fixation of the spleen the membrane further atrophies and the stomach encroaches as in the human spleen. But where there is mobility, *i.e.* not good dorsal

fixation, the anterior part of the lower surface is colic not gastric. Thus we may see the human foetal spleen with the remaining lieno-mesocolic (renal) fold and the anterior part of the gastro-splenic omentum extending to the extremities of the anterior and posterior processes, and practically shutting off the lower surface which is related to colon only. This is associated with a greater amount of mobility than is present in the human adult spleen.

It is worthy of note that broadening of the base of the mesentery, *i.e.* fixation of the proximal colon, begins from the mesial fold also, spreading from above downwards. Similarly, further fixation of the distal (descending) colon spreads downwards from the splenic fixation or flexure. The supporting phrenico-colic fold and the suspending lieno-phrenic, also lateral processes from the spleen to the abdominal wall, are not biological but physiological membranes freely modified to meet local conditions.

This article forms part of a monograph presented at the June meeting of the Anatomical Society on "The Digestive Glands and Spleens in Monotremes and Marsupials." As the research was carried out at the Royal College of Surgeons, it is scarcely necessary to add my indebtedness to Professor Keith, and especially to his Cavendish Lecture of last year, which gave us a new conception of the biology of the gastro-intestine. The drawings were made from my original dissections, now in the possession of the College, by Mr W. Finnerty.

THE FORMATION OF THE PARS MEMBRANACEA SEPTI.

By J. Ernest Frazer, F.R.C.S., St Mary's Hospital, *Professor of Anatomy in the University of London.*

The *pars membranacea* is not only the thinnest portion of the interventricular septum, but is also in part of its extent a structure separating the right auricle from the cavity of the aortic vestibule; it cannot therefore be considered as merely a part of a structural system, more or less simple, which divides the heart into right and left sides, for the aortic vestibule is formed to the right of the plane of the interventricular septum, and is associated with the region of the earlier bulb.

Some little time ago it was suggested to me by Sir John Broadbent that a series of models showing the main points in cardiac development would be of value in demonstrating to clinical students the bearing of these points on certain lesions of the organ. I undertook to make such a series, and used the sections of embryos of 5 mm. and upwards which I possess, in the work. Many of the models were so cut up in endeavouring to follow the development as exemplified in them that they were useless for subsequent demonstration: this, however, caused me little regret, for I had determined at an early stage that the purpose with which the work had been undertaken would be served best by constructing "schematic" models—made with a free hand, founded on the actual reconstructions, but only showing the general and main conditions, so that they would bear to the real models the same relation that a scheme or diagram on paper bears to the structure or conception of which it is used as an illustration of some particular aspect or condition. Anyone who has worked with reconstruction models of the heart will agree, I think, that they are very difficult to read, after the earlier stages, owing to the rapidly growing complexity of detail and inability to see more than a small part of each cavity at once, and such models would certainly be quite useless for the purpose of teaching students.

The subject of the present paper presented itself as an important one early in the work, because it seemed that clear-cut ideas on the formation of the region were necessary for a proper understanding of development in the immediate neighbourhood. Three of the schematic models illustrate this subject, and I propose to utilise the plan of their construction in the

description; they represent the bulbar and ventricular parts as simple smooth-walled cavities, opened and exposed by the removal of the ventral wall, so that the continuous cavity, necessarily flatter than is actually the case, is seen from the atrial opening to the arterial extremity where the aortic stem begins.

A diagrammatic rendering of the state of things found at a relatively early stage is seen in fig. 1. The cavity of the bulb is still easily distinguished, being partly separated from that of the ventricle by the bulbo-

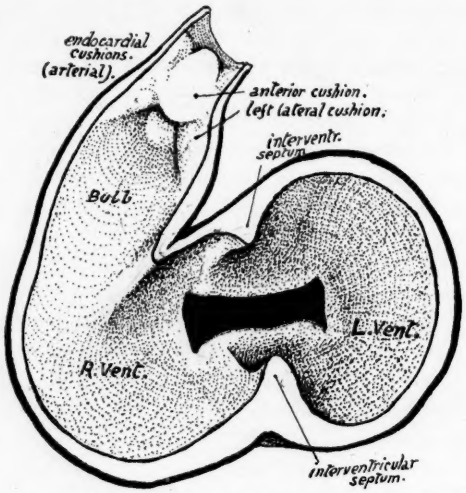

FIG. 1.—Diagram showing the relations at an early stage between the auriculo-ventricular opening and ventricles, the cavity of the bulb, and the bulbo-ventricular ridge. The distal cushions of the bulb are shown in a more differentiated state than they really exhibit at this stage.

ventricular ridge, elongated and spur-like on section; owing to the presence of this ridge, the cavities of bulb and ventricle become continuous to the right of the position occupied by the auriculo-ventricular opening. The interventricular septum is very low, leaving a wide passage between the two ventricles, and the lower end of the septum reaches the right tubercle of the lower a.-v. endocardial cushion, while its upper end runs into the bulbo-ventricular spur, near its base. The arterial endocardial cushions are shown at the upper end of the bulb; it must not be forgotten that these figures are only schemes, and that the cushions in an embryo whose ventricular development would be at about the stage seen in the

drawing, would be merely indefinite thickenings. These cushions are four in number, and the two that are placed laterally are represented as not yet joined, so that a single opening exists between the anterior and posterior cushions leading from the undivided bulbar cavity to the single aortic stem.

It is plain that no direct passage can be made between the left ventricle and the aortic end of the bulb so long as the ridge exists between the bulbar and ventricular cavities, and this ridge now commences to atrophy, or at any rate to disappear, as is well known. I think that the process is more than a passive one, as is perhaps usually taught, and that, although there may be merely a failure in growth at first, there is an actual degeneration coming into play very soon: such, at least, is the opinion I have formed from the examination of sections, and the assumption appears to be necessary to account for the practically complete disappearance of the ridge and wall in its neighbourhood. But, whatever may be the nature of the agency bringing it about, there is no doubt of the fact of the disappearance of the ridge, and, with this, new possibilities open up for further development of the bulbo-ventricular complex.

The stage of its formation on which the heart enters now is illustrated in fig. 2; here the cavity of the "bulb" no longer opens downwards into the ventricle to the right of the a.-v. orifice, but directly over its right-hand portion. This new relationship is not attained by any special extension of the a.-v. opening towards the right: the opening has become wider with the increasing ventricular width, but that this growth is purely proportionate is evident when we look at the situation of the interventricular septum. It is, then, the disappearance of the intervening bulbo-ventricular ridge which allows the lower opening of the bulbar region of the cavity to present a wider lumen and to become continuous with the ventricle much more to the left than is possible in the earlier stages. The remains of the ridge are shown in the diagram as a low crest between the right end of the a.-v. opening and the posterior arterial cushion. The direction of the ridge, like the somewhat upturned extremity of the a.-v. opening, is perhaps to be referred to the combined effects of the growth of the right ventricle, and the disappearance of all but the basal portion of the ridge.

A change is seen in the arterial endocardial cushions, in that the two lateral cushions are now shown as fused across the centre of the lumen of this part of the bulb, thus dividing it into two openings, anterior and posterior, which are continuous in their turn with the two distinct arteries into which the arterial stem has been divided by the aortic septum. The aortic septum is not indicated in the figure: it would meet and become con-

tinuous with the upper aspect of the fused cushions if it were put in, so that the aorta would reach the posterior opening and the pulmonary artery the anterior one. The course which must be taken by the aortic blood from the left ventricle is indicated by the arrow: its channel must be still further hollowed by the complete disappearance of the bulbo-ventricular ridge, and the fusion of the a.-v. cushions will afford a continuous floor for it, separating it from the cavity of the right auricle and constituting therefore the upper part of the *pars membranacea septi*. In

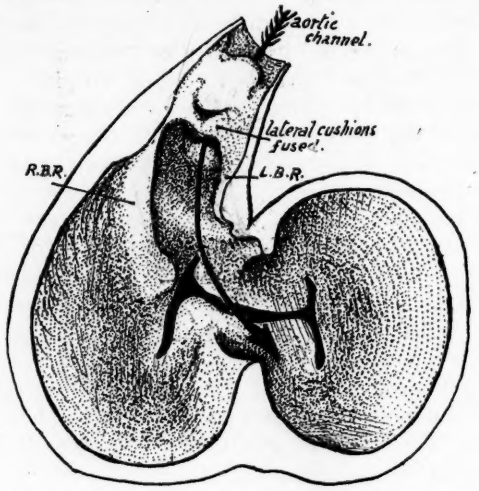

FIG. 2.—To illustrate the intermediate stages of the formation of the two channels and pars membranacea.

R.B.R., L.B.R., right and left bulbar ridges. The arrow marks the situation and direction of the aortic channel.

the meantime, other changes are taking place in this region, concerned with the closing in of the aortic channel and its separation from the corresponding aditus to the pulmonary artery. These are shown in the figure in the shape of two "bulbar" ridges: the left ridge is on the dorsal and left wall at its upper end and on the ventral and left wall below, while the right ridge is on the right wall, rather ventral in its upper part and decidedly more dorsal below, where it reaches the right side of the a.-v. opening. The ridges are continued above into the arterial cushions, which are fused, so that, when they meet, the ridges would form a roof to the aortic channel continuous with the spiral septum formed by the arterial cushions and the arterial septum above these.

The lower end of the left ridge is at first separated from the upper part of the interventricular septum by the remains of the bulbo-ventricular ridge, but as this disappears the two structures become continuous, the left ridge, however, reaching the right side of the septum, as might naturally be expected, seeing that it is developed in the bulbar region.

These two ridges are, of course, the "proximal bulbar swellings" of Tandler's description. It is, perhaps, hardly necessary to point out that they and the whole bulbar region have been shown in the diagram as more elongated, for the sake of clearness, than they appear in the actual condition. Also, for similar reasons, the original direction of the arterial end of the heart has been preserved; actually, the ventral and dextral growth of the right ventricle leads, with the atrophy of the dorsal and left wall of the bulbar region, to an increasing obliquity, dorsally and to the left, of the arterial portion of the heart, but these are all non-essential points in the description of the mode of formation of the *pars membranacea septi.*

The essential matters are the apposition and junction of the upper and lower a.-v. cushions and the disappearance of the bulbo-ventricular ridge, so that the dorsal and left arterial cushions are brought very near to the right end of the a.-v. region. At the same time, or probably usually just before this, the aortic channel is separated from the pulmonary subdivision by the meeting of the bulbar ridges, the extension of the fused (lateral) arterial cushions, and the junction of this compound septum with that between the ventricles: it will perhaps be most convenient to deal shortly with this first—the septum between the right and left channels.

In fig. 3 the larger drawing represents the elements which enter into the composition of the septum between the two channels, in the way in which they are shown in the schematic model. The lower parts of the bulbar ridges meet, but they are separated above by the downgrowth of the fused lateral arterial cushions: the right ridge grows across the auriculo-ventricular opening[1] to join with the other ridge, and shortly after this the lower free edge of the septum formed in this way fuses with the free margin of the interventricular septum, with which the left ridge is, as has been seen, already continuous. The smaller drawing is from a model of a heart from an embryo of 16 mm. length, showing only this region, dissected to exhibit the composition of the dividing septum: in this the proper obliquity of the parts is, of course, a factor in the appearance, the pulmonary

[1] This existence of a new transversely directed upper limit to the right a.-v. opening may afford an explanation of the presence of three cusps in the valve of this side, contrasting with the simpler original form of the left opening: this, however, is only a suggestion, in conformity with the disposition of the cusps on each side, for I have not investigated the matter further.

orifice looking almost directly toward the observer, and the aorta, where it is cut, being far above the level of the aortic valves. It is evident that, when the division between right and left sides is completed in this way, there is no closure of the true interventricular foramen, for the structures concerned in the separation between the two channels reach the margin of the foramen and leave its lumen patent, affording passage to the blood from the left ventricle to the aortic channel.

While this, then, is the way in which the aortic channel is being cut off

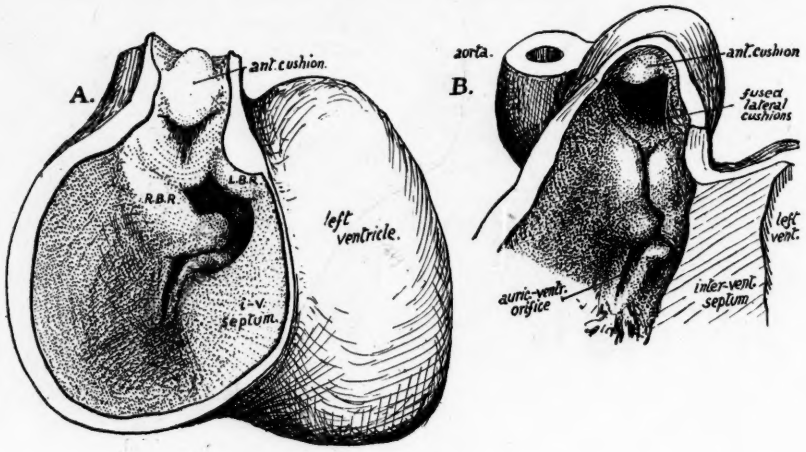

FIG. 3.

A. Diagram to illustrate the further growth of the bulbar ridges and arterial cushions to complete the division into two channels.

B. View of the infundibular aspect of the dividing septum, from the "dissected" reconstruction model, 16 mm.

from the rest of the region, the floor is formed in the manner indicated or foreshadowed in fig. 2. The fused a.-v. cushions make the main part of the bed of the channel, the bulbo-ventricular ridge has completely disappeared, and consequently the region of the arterial cushions lies just above the right end of the fused a.-v. cushions. Fig. 4 is from a reconstruction model (16 mm.), and shows the position of the cushions. A is the upper a.-v. cushion, and B the lower one, larger and better marked than the other in the model. The interventricular septum is partly cut away, but its area of contact with the lower cushion is indicated by interrupted lines: the same method is used to show the position of the right bulbar ridge, the base of which only is visible in the illustration. Evidently the right ridge, when

it crosses the line of the right a.-v. opening, rests on the upper surface of the right tubercle of the lower cushion, the front part of which projects slightly below it (*cf.* fig. 2). Thus it is along this cushion that the right ridge comes into relation with the interventricular septum.

The bed of the aortic channel is seen to be made from a part of the lower cushion and the whole thickness of the right portion of the upper cushion. The right tubercle of the upper cushion is marked *x*, and just

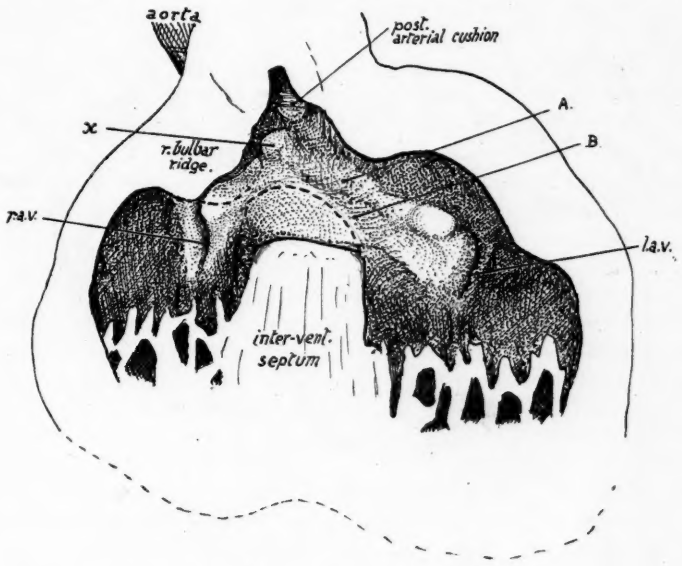

FIG. 4.—The floor or dorsal wall of the aortic vestibule, from the 16-mm. model, simplified.

A, B, upper and lower auriculo-ventricular cushions; *x*, right tubercle of upper cushion; *r.a.v.*, right a.-v. opening; *l.a.v.*, left opening.

above this is seen the posterior arterial cushion. The proximity of the two structures is accounted for by the total disappearance of the bulbo-ventricular ridge, and probably of the left dorsal wall immediately adjacent to it. The right tubercle, *x*, is thus left with only a very narrow strip of tissue between it and the posterior arterial cushion.

The model from which the last figure was drawn is one of two made from embryos of 13 and 16 mm. respectively, which were constructed with a view to showing the final position of the various parts described above. In these embryos junction of the several parts has occurred, but the lines of

junction are still nearly altogether apparent. In the 16-mm. specimen the sections are particularly clear and good, and the model made from it gave the figures shown in figs. 4 and 3, B. The "suture lines" were drawn and cut with the rest of the sections in which they occurred, with the result that, when the models were made, the component parts were shown very clearly. The 13-mm. embryo was treated in the same way, and the model cut up afterwards: although the sections of this specimen are very good, yet an excessive amount of blood in the heart made it necessary to refer continuously to the higher powers of the microscope to decide doubtful points in the drawings, wherefore a larger model was not made from it; but the results obtained were practically the same as in the other case—in some ways even more definite. In an embryo of 18 mm. the sections did not exhibit the original divisions of the parts with enough clearness to lead one to make a similar kind of model.

By adopting these means, actual confirmation became possible of the impressions gained from the earlier stages as to the mode of formation of the membranous part of the septum. It was seen that the upper cushion—perhaps in association with the smaller growth of this part of the ventricle, and even, it may be, the atrophy towards the right—is much less extensive than the lower one, the size of which may possibly be connected with the greater growth of the lower parts of the ventricles. Moreover, it became evident that, to make a proper channel for the stream to the aorta, the ventricular surfaces of the cushions were rendered concave and hollowed in an oblique direction, the hollow (fig. 4) affecting the lower cushion more toward the left and the upper one more toward the right. This part of the channel wall is separated, therefore, on the left of the middle line from the left auricle, and further on from the right auricle, by the endocardial cushions. It is only that part which comes into relation with the right auricle, *i.e.* the part made by the right end of the upper cushion, which forms a portion of the described *pars membranacea*; but this limitation is in all likelihood due to the conception of the *pars membranacea* as a portion of the dividing septum between right and left sides, whereas it would perhaps be more reasonable to look on the separating wall between auricular and ventricular region as being of the same value on each side, made from the same structures, and to describe both these areas as continuous, *via* the lower cushion, with the proper interventricular septum.

When the a.-v. cushions fuse, the right and left openings remain as subvertical slits, bounded on their inner sides by the upper and lower tubercles of the corresponding cushions. When the right bulbar ridge grows across the right opening (fig. 4) it cuts off the upper part of this, and leaves the

definite opening formed only from the lower portion of the vertical slit, that part which is bordered by the lower portion of the lower cushion. The upper part, beside the upper tubercle, closes and thus completes the bed of the channel, but the closure would appear to be subsequent to the formation of the roof of the channel: in the 13-mm. embryo a communication can still be followed between the channel and the auricle; in the 16-mm. specimen the track is closed at its aortic end for the thickness of some sections, while in the embryo of 18 mm. no indication of its former position could be recognised with any certainty. I could not be certain whether the upper part of the left opening persisted or not.

It is advisable, perhaps, to call attention again to the fact that not only are the figures illustrating the earlier modes of formation purely schematic but even the figures drawn from the actual model have had to be simplified to some extent to make them of use for the purposes of this paper—for the intricacies which make the models so hard to read when one can turn them about in the hand would render the drawings of their actual state quite unintelligible, in all probability, to the reader who has no opportunity of handling them. It might not be considered out of place, therefore, if a little consideration were given to some of the points which are not illustrated by the diagrams.

To take, for example, the two bulbar ridges. As has been already pointed out, these are not so long as they are represented in the diagrams, and they are, moreover, much thicker, so that their lower ends form, where they meet, a thick but low mass projecting somewhat into the cavity of the right ventricle (fig. 4). Thus a relatively thick septum exists between the two channels. The upper parts of the ridges are separated by the downgrowth of the fused (lateral) arterial cushions, which makes a mass of remarkable thickness: the prolongation downwards of the cushion-mass is in the form of a double tongue, each tongue fitting it between the pulmonary or aortic surface, as the case may be, of the ridges. Thus, in fig. 4, B, the tongue seen foreshortened between the upper parts of the ridges is only one of the downgrowths, for a corresponding formation lies between the ridges on their deep or aortic aspect, and the two tongues are separated for some distance by a cleft passing upwards between them, filled by the basal portions of the ridges. Moreover, the axis of each tongue passes in a different direction; that of the deep downgrowth, compared with that of the other, is directed markedly to the left. Thus the whole mass exhibits a twist in conformity with the general spiral seen in the structures which separate the aortic and pulmonary vessels and channels.

In the diagrams the interventricular septum is shown reaching the lower a.-v. cushion, close to the right tubercle, but I do not think it would be

correct to look on the solid septum proper as actually reaching the cushion. It seems to reach its lower edge and, above this, only to be connected with it by loose trabecular structure, through which a partly interrupted passage can be traced between the ventricles. Even when the whole system is closing in, this arrangement seems to hold, and here, then, the septum is formed presumably by the aggregation of looser trabeculæ, and perhaps by part of the cushion above this. The addition of loose trabecular tissue to the septum would also appear to take place on its surface, particularly on the left side: the 13-mm. model shows such tissue, seemingly pushed against this surface of the septum by the pressure of the blood-stream passing to the aortic channel, and probably the thick septum seen in later stages owes some of its size to the addition of this trabecular structure to its surfaces as the ventricular cavities get more defined and the channels opened out.

It has also been pointed out that the arterial stem is really directed more obliquely than shown in the drawings. This is due to the degeneration and disappearance of the left and dorsal wall of the bulbar region. As a result this part of its wall necessarily shortens, and in fact its wall in this part practically disappears except in its distal portion, where the cushions lie which form the semilunar valves: in this way these (dorsal and left) valves come to lie just above the *pars membranacea*. But the atrophy does not affect the front and right walls of the bulb, so that in this part more of the original cavity of the bulb might be expected to persist; but whether the wall of this part is invaded by the ventricular musculature or is pushed up by it as it grows seems a difficult question to answer satisfactorily. It is sufficient for present purposes to recognise that the disappearance of the bulb-wall is most marked dorsally and on the left, in the region of the left channel, with resulting obliquity of the part: the floor of the aortic channel becomes very short, the septum between the two channels is longer, and the front wall of the infundibulum longer still.

Summing up shortly the results which I have endeavoured to set forth in the preceding pages, it may be said that the *pars membranacea* is made from the fused a.-v. cushions, the auriculo-vestibular part from the right end of the upper cushion, the interventricular part from the lower one with some trabecular structure joining this with the proper interventricular septum. The disappearance of the bulbo-ventricular ridge is a necessary preliminary to the formation of the aortic vestibule, and is also the cause of the shortness of the dorsal wall or floor of the vestibule, and the proximity of the *pars membranacea* and the dorsal and left aortic valves. The true interventricular foramen does not close, but remains patent as the opening into the aortic vestibule from the left ventricle. The septum separating the

cavities of the aortic vestibule and the infundibulum is made by the junction of two bulbar ridges, which join the free edge of the interventricular foramen below, and are separated above by a marked downgrowth of the fused lateral endocardial cushions of the arterial end of the bulb. Only the lower portion of the right auriculo-ventricular opening remains as the permanent right opening, the upper part being closed and lying in the floor of the aortic vestibule: this upper moiety is cut off from the lower by the growth of the right bulbar ridge across the opening to meet the margin of the interventricular septum. It is doubtful whether the permanent left opening is the whole or only a part of the earlier one.

BILATERAL DUPLICATION OF THE URETER.

By Douglas G. Reid, M.B., Ch.B. Edin., M.A. Trin. Coll. Camb., *Anatomical Department, University of Cambridge.*

Cases of double ureter are so well known that little need be said regarding many of the features presented by the example (found in an old male) of bilateral double ureter to which I here refer, "distinctly rare" (especially when we exclude cases in which there are not four separate openings into the bladder) though it be.

There were no other outstanding variations in the urinogenital organs or in other parts.

There were no accessory renal arteries on the right side, although the right kidney lay somewhat lower than usual. On the left side a relatively small accessory renal artery (cut by the dissectors) entered the anterior, surface of the left kidney (normally placed) above the level of the hilum.

The kidneys were distinctly enlarged. Although this is doubtless usual, it was here, in part at least, due to pathological causes (amyloid degeneration apparently secondary to tuberculosis of the lungs); and the downward displacement of the right kidney was obviously secondary to enlargement of the liver. Anatomists are sometimes too prone to overlook associated pathological conditions. As they were present here, it is unnecessary to go into details regarding the size of the kidneys. Normal in general external form, there were no indications that the parts of either kidney corresponding to a ureter had ever been separate from one another.

The renal ducts passed from their upper ramifications (to which I shall again refer) downwards parallel to one another.

On each side they had the course and relations presented by the normal single ureter.

In the abdomen, and in the upper part of their intra-pelvic course, although lying close together, they could readily be separated from one another, and their coats were distinct. But in relation to the ductus deferens they became firmly welded together, so that even with the aid of a knife it was extremely difficult to indicate the line of separation between the two tubes. Indeed (see fig. 1), immediately before (on the right side) and after (on the left side) crossing the ductus deferens, the ducts were apparently "fused" into a single thick-walled tube, circular as seen in transverse

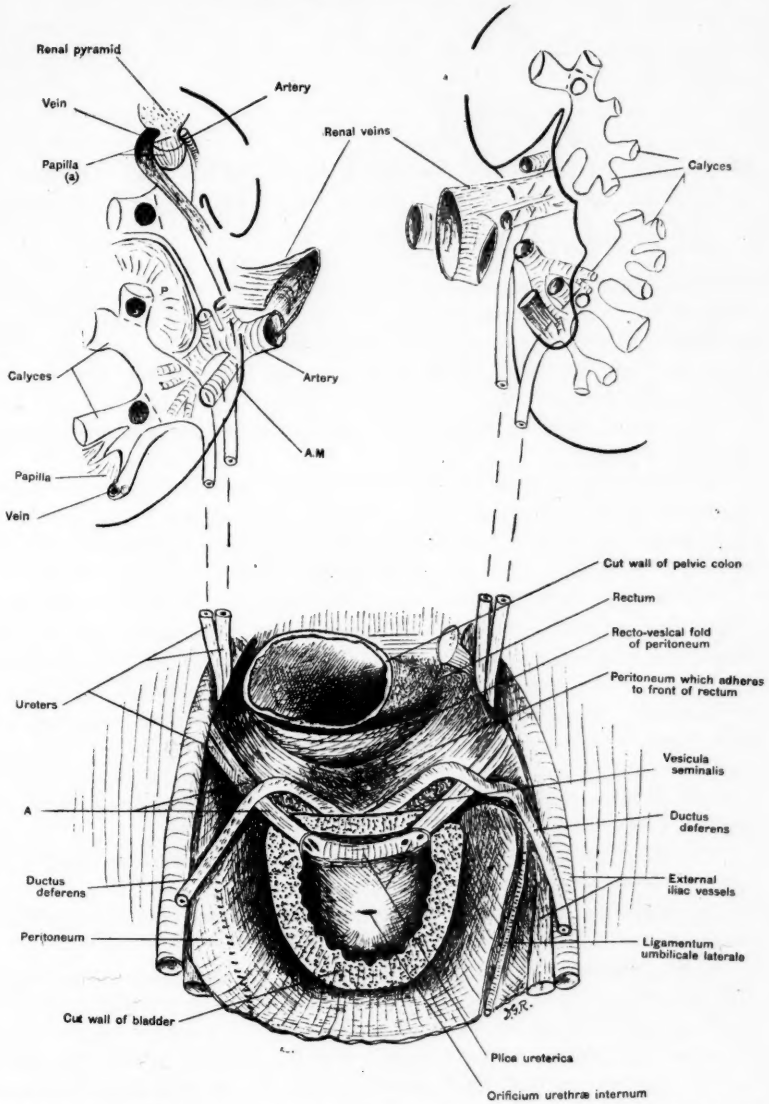

FIG. 1.—The kidneys are represented as lying lower than was the case. The bladder is viewed from above and slightly from in front. A indicates the apparently single portion of the right ducts. The whole of the convex border of the recto-vesical fold of peritoneum adheres to the rectum, so that the fold is purely rectal. One-half actual size.

section. Unless the interior of the bladder had been carefully examined, the fact that the lumen of each duct remained distinct might readily have been overlooked. As is usual, the ureter which drained the urine from the upper part of the kidney opened medial (more so on the left side, see fig. 1) to the opening of the ureter from the lower part. For this reason it "is more subject to compression" (Riesman, Hektoen-Riesman's *Pathology*, 1901).

The bladder was small and contracted. The medial openings of the ureters were one inch apart and nearly the same distance from the internal urethral orifice.

A transverse section (see fig. 2) for microscopic examination was made of the apparently single ureter (A, fig. 1).

The middle coats of the two tubes, in which the bundles of muscle-fibres were for the most part longitudinal, were completely blended over the line between them. Thus there was no indication of a connective-tissue partition between two sets of fibres; and the tunica adventitia formed a cylinder common to both tubes. Indeed, it was specially remarkable that some bundles of transverse muscle-fibres lay over the line between the tubes, so that these had undoubtedly been compressed, at the same time, by transverse fibres common to both.

Many muscle-bundles, for the most part longitudinal but some transverse, were also present between the tubes, without there being any line of demarcation between longitudinal bundles special to either, although at places the transverse fibres appeared to belong more to one than to the other tube (fig. 2). Thus transverse fibres were present capable of acting on either duct, and also of compressing both together.

Thus, in double ureter, although the middle and outer coats of the tubes may fuse together below and the duct appear single, one should always be careful to determine if there is not really a double tube.

The manner in which the ducts terminated in relation to the sinus of each kidney is accurately shown in fig. 1. A greater number of calyces (6 as compared with 3, and 8 as compared with 7 minor calyces) are in connection with the two shorter ducts than with those which extend more cranially. This is especially the case on the right side; and a similar condition, present in cases of double ureter recorded by A. T. Kerr (*The Anatomical Record*, Feb. 1911, p. 55), is regarded as a reason why the view expressed by Huntington should not apply to such cases. But doubtless it might to Huntington's case. In this connection, see also Keibel and Mall's *Embryology*, vol. ii. pp. 867–8.

On each side (see fig. 1) the arteries (and veins) which passed through the hilum and came into relation with the shorter duct crossed first in front

of the longer duct, and then passed one in front and the other behind the shorter duct. The arteries (and veins), in relation to the longer ducts alone, lay in front of the duct on the right side, where there was only a relatively small twig representing a retro-pelvic artery, and on the left side passed one in front and another, equally large, behind the duct (fig. 1).

FIG. 2.—Microphotograph. The two lumina are seen. The dark areas are muscle-bundles. Only a relatively small part of the tunica adventitia is shown at the top of the photograph.

The left kidney was distinctly larger than the right; and it will be seen that there was a considerable difference on the two sides, both in the number of calyces and in the size of the ducts. Lateral to the anterior margin of the hilum the ducts of the right kidney were distinctly expanded (fig. 1). This obvious expansion was not present on the left side. These points are most noteworthy. Ralph Thompson (*Journ. Anat. and Phys.*, vol. xlviii., April 1914) states his belief that in certain conditions, owing to differences in anatomical relations, "blood, at any rate, escapes with greater difficulty

from the right kidney than from the left, and that therefore the flow of urine along the right ureter may be retarded also."

The expansion of the upper parts of the right ducts was in part due to a pathological cause which I shall indicate. But it might be worth while looking for indications of the features which I describe in other specimens in which the conditions tend to be similar, and especially in thin subjects, where there is a relatively small amount of protective adipose capsule. It is noteworthy that this is prolonged into the slit-like renal sinus.

In the adult the hilum of the kidney usually looks inwards and forwards, although its anterior border is normally convex, and its posterior border straight or somewhat notched. But in this connection one must, of course, remember the orientation of the kidney. "La face antérieure regardant fortement en dehors il en résulte que la partie postérieure du bord interne est plus rapprochée du plan médian."

The direction is due, of course, to the forward projection of the bodies of the lumbar vertebræ coated by psoas major, against which the anterior margin of the hilum is not normally pressed.[1]

But on the right side, doubtless in association with the disposition of the main arteries,[2] the anterior margin of the hilum was convex and extended unusually far medially, so that the hilum looked directly inwards, and its anterior margin lay in close relation to the psoas major. At its lower part it was separated from this muscle only by the ducts and a small

[1] As in the case of the head and neck (the visceral septum), I have found in the abdomen what may be termed a foundation stone (the posterior abdominal wall) of great value to the student in building up his anatomy of the part to the best advantage. Others must, I feel sure, follow this plan. Before touching on the intra-abdominal viscera in detail, the bones, muscles, and all the parts which enter into the formation of the posterior abdominal wall are described, and the form of this wall in relation to the form and direction of the viscera, diaphragm, etc., is dealt with. Special attention is thus early directed to the forward projection of the lumbar vertebræ because it helps the student to understand, and keep in mind, what are often mere statements made in the books regarding the direction of the viscera and their ducts and the blood-vessels. In addition to explaining why the kidneys and suprarenal glands face in a certain direction, it explains, *e.g.*, why the body and head of the pancreas of the adult face in different directions, why the pancreatic duct in the head of the pancreas inclines backwards, the backward course taken by the renal and splenic vessels, etc. It helps to explain, in association with the presence of the inferior vena cava and aorta, and, as Jonnesco points out, with the relatively smaller size of the adult kidney as compared with that of the child at birth, why the second part of the duodenum lies in a plane posterior to the more median parts. The parts are built up very largely upon the posterior abdominal wall as a "foundation stone." Thus, before dealing in detail with the stomach and intestines, the kidneys and their ducts are described, and then the suprarenal glands, liver, spleen, pancreas.

[2] See A. H. Young and Peter Thompson, *Journ. Anat. and Phys.*, vol. xxxviii. p. 1.

In connection with this, it was noteworthy that the calyces represented by the dark circles in fig. 1 were directed forwards to be attached around their associated papillæ, whilst, on the left side, the calyces represented by the light circles passed backwards. On this side the anterior "labium" of the hilum was poorly developed.

amount of adipose capsule. The liver was enlarged, and the ducts, where they crossed the anterior margin of the hilum, had undoubtedly been unduly compressed between this and psoas major coating the unyielding vertebræ. Indeed, a distinct groove was present on the kidney, indicating where the shorter duct had been compressed. In this way, on the right side, a slight hydronephrosis had been produced.

In the normal kidney, vessels may be found moulded over any convexity of the sinus wall. This moulding of the renal vessels was very obvious in the specimen, especially on the right side, where the formation of a cortex-coated convexity (P, surrounding the highest of the lower set of calyces in fig. 1), between the upper and lower parts of the sinus, had caused three large arteries and veins to be moulded around it in the form of a circle, incomplete only in one-fourth of its circumference.

In the normal kidney a vessel may sometimes be found grooving the sinus wall; and sometimes a papilla may be grooved by a vessel which is wedged in between it and the adjacent cortex. The grooving of the projection P and of the renal papilla (*a*) (see fig. 1) was especially well marked, and was due especially to the veins. The grooving of the papillæ was not so obvious on the left side, where also the veins in relation to the papillæ—which, however, were more numerous—were decidedly smaller than on the right side.

There seemed little doubt that the blood had escaped "with greater difficulty from the right kidney than from the left."

From the close anatomical relationship that the vessels may bear to a papilla, one can imagine that if pathologically enlarged they might, in some cases, interfere with the outflow of urine from the collecting tubes.

In diseases of the kidney "one astonishing feature stands out quite clearly. The right kidney is affected much more frequently than the left" (Ralph Thompson).

This is a consequent of special normal relations, in some cases associated it may be, with the anatomical conditions I have indicated.

THE GENITALIA OF THE CHEIROPTERA.

By Frederic Wood Jones, *Professor of Anatomy in the University of London, The London School of Medicine for Women.*

Part I.: THE MEGACHEIROPTERA.

Material.

Of the fruit-eating bats I have examined examples of *Pteropus medius* (Dobson Cat., p. 51), of which species I have had spirit specimens of both sexes, which I owe to the kindness of Professor G. Elliot Smith, and fresh material from the Zoological Society of London.

For many specimens of *Cynonycteris ægyptiaca* (Dobson Cat., p. 74) I am indebted to Lord Rothschild. This series includes adult males and females, and one female which is apparently newly born. Other examples of the same species I have collected for myself.

Reproduction.

The presence of a more or less extensive uropatagium in many species would seem to offer an effectual impediment to copulation in the normal quadrupedal manner. I have been told by several non-scientific observers that this interfemoral membrane is circumvented in the act of copulation by the approximation of the ventral surfaces of the two individuals. Dr C. W. Andrews, who during his residence on Christmas Island had exceptional opportunities for observing the life-history of *Pteropus natalis*, confirms this account, and has been good enough to furnish me with some details. "The female," he tells me, "hung head down from a branch in the usual position, and the male hung facing her from the same branch, or from her legs, I am not sure which. Then there was a great flapping of wings and most horrid screeching which lasted for a considerable time."

On the other hand, Knud Andersen, writing of *Cynonycteris collaris* = *Rousettus leachi* and quoting (Wunderlich, *Zool. Garten*, xxxii. pp. 78–81, 1891), says that "during the act of copulation the male is suspended (as usual by the hind feet) behind the female, its underparts being in contact with the lower back of the female; an embracing with the anterior extremities does not take place."

Although some fruit bats, especially the members of the genus *Pteropus*, are easily kept and observed in confinement, it is, for some reason, difficult to obtain females. The living Pteropines imported into the London markets are usually males.

This state of affairs may result from a real numerical disproportion of the sexes, or to some sexual difference of life habit which renders the males more easily obtained. In collecting a series of embryos of *Pteropus natalis* Dr C. W. Andrews reckoned on obtaining only one female among every nine individuals shot. This rather striking feature of the economy of bats will be referred to again in dealing with the Microcheiroptera. Pteropine bats have been known to produce young in captivity, and both in London and Cologne these young have been reared at the Zoological Gardens.

Apparently all the Megacheiroptera produce but one offspring at a birth, and the reproductive life of the individual is probably late in its onset.

Sclater records the birth of a young *Cynonycteris collaris* in the gardens of the Zoological Society of London in 1870. The female was purchased on 1st November 1869, and was placed in a cage with a male of the same species: copulation was never witnessed. The young one was born on 27th February 1870, and, as Sclater says, "it is therefore possible, though not probable, that the female might have been pregnant when received." According to Andersen (*op. et loc. cit.*) the period of gestation of this species (which he indicates by the name *Rousettus leachi*) has been determined at the Zoological Gardens at Cologne to be fifteen weeks.

The young are born covered with short smooth hair (Sclater), and they cling tight to the mother's nipples, under cover of her folded wing membrane, until they are four months old (Andersen); at eight months they are not yet fully grown.

Reproductive System.

Robin has described the anatomy of the internal genitalia of nine species. The examples which he examined embraced the following species: *Epomophorus monstrosus* (Dobson Cat., p. 6), *E. comptus* (Dobson Cat., p. 13), *Pteropus medius* (Dobson Cat., p. 51), *P. rubricollis* (Dobson Cat., p. 24), *Cynonycteris amplexicaudata* (Dobson Cat., p. 72), *Cynopterus scherzeri* (Dobson Cat., p. 84), *C. jagorii* (Dobson Cat., p. 87), *Harpyia cephalotes* (Dobson Cat., p. 88), male only, and *Eonycteris spelæa* (Dobson Cat., p. 94).

The description and illustration of the internal genitalia, as given in this monograph, leave but little room for additional observations; but the external genitalia are not treated in an exhaustive manner.

Dobson, in his Catalogue of the Cheiroptera, has given some account of a few general features of the reproductive system, but, again, the external genitalia receive but little attention. In the second edition of this Catalogue, by Knud Andersen, even these meagre details of anatomy are omitted. There are a few papers, scattered in the literature, which deal with special points in the anatomy of the reproductive organs; but the accounts given in most works upon the Mammals may be traced to the researches of Robin. In the following descriptions I shall therefore make only brief reference to the anatomy of the internal genitalia, most attention being paid to those details of the external genitalia which seem not to have been fully described.

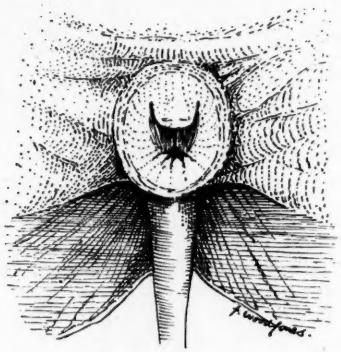

Fig. 1.—*Cynonycteris ægyptiaca*. External genitalia of a young female.

Female.—The internal genitalia of the female exhibit the curiously primitive condition of completely separated uteri. In some forms (as *Epomophorus* and *Cynonycteris*) each uterus possesses its own separate os uteri which opens into the common vagina; whilst in others (as *Pteropus*) two elongated uterine cornua are united outwardly in their lower portions into a corpus uteri, but this uterine body is completely septate within. In both cases the vagina terminates at the vulva in common with the urethra, there being no urogenital sinus. A hymen has not been described, and I am unable to detect it in any of my specimens.

There is a very complete ovarian capsule in all species. The Fallopian tubes are narrow, short, and not very tortuous.

The external genitalia of the female exhibit several points of interest. In the young female of *Cynonycteris ægyptiaca* (see fig. 1) the lips of the extroverted cloaca surround, as a prominent raised margin, the genital

tubercle, the urogenital orifice, and the anus. The genital tubercle is bent caudad, and covers the urogenital orifice completely, while the clitoris, with its inconspicuous ridges, has already taken on that flattened form which is so characteristic of the adult.

In the adult female (see fig. 2) the prominence of the cloacal margins has practically disappeared; so that defined labia majora do not exist. There is, however, a depressed area which immediately surrounds the uro-

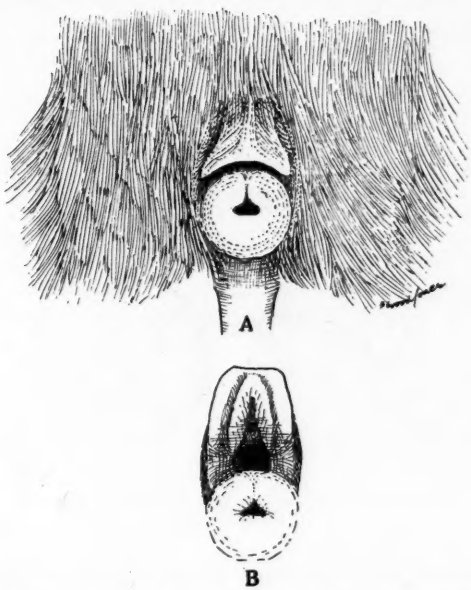

FIG. 2.—*Cynonycteris ægyptiaca*. A. External genitalia of adult female. B. External genitalia of another example with the clitoris raised.

genital area as a sulcus. This sulcus represents the cloacal recess, and corresponds to a sulcus nympho-labialis in such animals as have well-developed labia majora. The region of the cloacal margins is defined by well-differentiated pubic hair, which differs from the general body hair in texture and in colour. The clitoris has become remarkably flattened, so that it, and its labia minora, form a leaf-like flap which covers the urogenital orifice and causes the vulva to appear as a slit-like orifice disposed transversely to the body axis. This transverse disposition of the vulva is very characteristic of the Megacheiroptera, and its similarity to the condition present in *Galeopithecus* is very striking.

The vulva itself is large, and the urethra opens just within its anterior margin.

In *Pteropus medius* the condition differs from the above in minor details only, the underlying plan being evidently the same.

The labia majora are rather more developed, and, over the separated pubic bones, make considerable eminences which correspond to a partially subdivided Mons Veneris: the sulcus nympho-labialis is rather better marked: but the flattening of the clitoris and its folds has not proceeded so far. The urethral orifice opens at the base of the clitoris, the vagina is

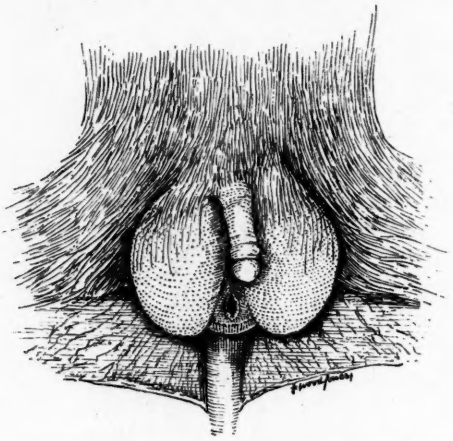

FIG. 3.—*Cynonycteris ægyptiaca.* External genitalia of an adult male, which, judging from the state of development of the testes, etc., is probably at the breeding period.

large, but the vulva is not so markedly elongated from side to side. The differentiation of pubic hair is better marked than in *Cynonycteris.*

Male.—There is nothing of particular note concerning the internal genitalia of the male, and all the details have been described by Robin. The testes in all the examples that I have examined have been in the scrotal pouches. This finding is apparently merely the result of too limited a survey of material, for it is generally stated that the descensus is periodic in all bats, Megacheiroptera and Microcheiroptera alike. The testes are rounded rather than oval, and the epididymis is large. The surface of both testis and epididymis is covered with a fine meshwork of pigmented lines in *Pteropus,* but this pigment is not present in *Cynonycteris,* nor, according to Robin, in the members of any other genera dissected by

him. The tunica vaginalis communicates freely with the peritoneal cavity. The vesiculæ seminales are large; the prostate does not entirely surround the urethra in all species, and when this is the case the deficiency is posterior, the anterior portion being developed. Glands of Cowper are present, and are generally very well developed.

The male external genitalia are principally noteworthy for that striking resemblance to the primate and human organs which attracted the attention of Linnæus. The penis in all is free and pendulous. It is covered by a fine skin, which is usually pigmented, and is devoid of hair except at its extreme base. A slight frænulum is present, and the well-marked

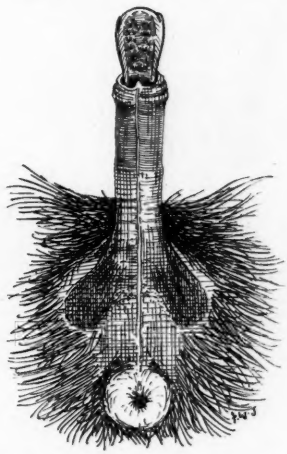

FIG. 4.—*Pteropus medius.* External genitalia of an adult male.

median raphé runs along the lower surface of the penis and extends across the perineum to the verge of the anus. A small broad ossicle is present in the glans. In *Harpyia* the ossicle is said by Dobson to be elongated, as it is in most of the Microcheiroptera.

In *Cynonycteris ægyptiaca* (see fig. 3) the glans is simple, and the urethral orifice is terminal. The testes in all the specimens that I have examined are very large, and the scrotum, which is pre-anal in position, is pigmented in most specimens. There is a small broad ossicle in the glans.

In *Pteropus medius* (see fig. 4) the penis is deeply pigmented, the glans being black. The urethral orifice is situated upon the upper surface of the glans, which has a slightly lobulated extremity. Upon the under surface

of the glans are a number of backwardly-directed corneous elevations which give a distinctly barbed character to this structure. These copulatory spurs are of interest not only as being reminiscent of the much larger structures present in some lower Mammals, but also because they have their representatives in human anatomy.

The scrotal area of *Pteropus* is deeply pigmented, but the pigment is

FIG. 5.—*Cynonycteris ægyptiaca*. Mammary gland of an adult female.

confined to two definite patches which do not extend over the whole of the fully distended scrotal area. Distinct pubic hair is well marked. There is a small broad ossicle in the glans.

MAMMARY GLANDS.

The mammary glands are two in number and pectoral in position (see fig. 5). The nipples are large, and in old specimens the breast tends to become pendulous. The gland tissue, as in all bats, extends for a remarkable distance backwards upon the surface of the M. serratus magnus; much

of it being actually situated upon the dorsal surface of the animal. This is evidently an adaptation to aerial life, and presumably is to permit of freedom of movement on the part of the great M. pectoralis major.

Pelvic Symphysis.

In none of the Megacheiroptera is there a ventral meeting of the pubic bones. In the females the gap between the two sides of the bony pelvis is considerable, and the divided pubis form well-marked elevations beneath the skin. In the males the approximation of the two sides is closer, but an osseous union seems never to occur.

Placentation.

The placenta is uniformly discoidal in the Megacheiroptera. Robin has given an admirable figure of the fœtus and placenta of *Pteropus Edwardsi* (*op. cit.*, plate viii., fig. 57), and Gervais has figured and described the fœtus and placenta of *Gnopterus marginatus*.

Summary.

The Megacheiroptera, judging by their genitalia, form a fairly well-defined group, characterised by a rather extraordinary blend of characters which are stigmatised as low with characters which are ranked as high. In many of these characters they overlap with the Microcheiroptera. The entirely double uterus is matched in but few Eutherian Mammals; it cannot fail to be regarded as primitive, and its presence in an animal producing a single offspring at a birth is noteworthy. The absence of a urogenital sinus might be regarded as remarkable were it not considered in conjunction with the condition of the pelvic symphysis. The whole form of the external genitalia shows obvious cloacal outfolding, and although I have not had the opportunity of studying the actual embryonic stages, I conceive it to be certain, from the examination of the young specimen of *Cynonycteris*, that this is the process followed in development. The Megacheiroptera, therefore, fall into the ranks of the Cloacaexplicata. The apparently transverse opening of the vulva, and the marked flattening of the clitoris and its associated structures, are features which, well developed in *Galeopithecus*, are seen again in certain Microcheiroptera.

I regret that so far I have had no opportunity of dissecting *Harpyia*, since in so many points of its visceral anatomy it appears to diverge from the rest of the Megacheiroptera.

Part II.: THE MICROCHEIROPTERA.

Material.

Of the Microcheiroptera I have had material comprising numerous examples of a fair number of species. M. Robin has recorded the conditions present in many species that I have been unable to obtain, and, as a result, some knowledge is to be had of a considerable array of members of most genera. But though the combined lists of species might at first sight seem fairly comprehensive, they represent but a very small contribution towards the work to be done in investigating the anatomy of the insectivorous bats, since, in so many cases, the systematic arrangement of genera and species seems to have but little natural basis when reference is made to the anatomy of the reproductive system.

Within the limits of a genus the genitalia may display very profound modifications in apparently closely allied species. Nothing short of a thorough examination, not of skins and teeth alone, but of the detailed anatomy of a thoroughly representative collection, could clear up some of the many uncertainties still existing as to the interrelationships of the extremely large number of species.

I append a list of the species that I have dissected, and in nearly every case the species has been represented by a large number of examples. I have added in brackets the name of the donor to whose kindness I am indebted for the material, and where no such name is inserted I have collected the specimens myself.

Rhinolophidæ.

(1) *Phyllorhina tridens*, Dobs., p. 127.

Vespertilionidæ.

(2) *Synotus barbastellus*, Dobs., p. 176.
(3) *Plecotus auritus*, Dobs., 178.
(4) *Vesperugo serotinus*, Dobs., p. 191.
(5) *V. noctula*, Dobs., p. 212.
(6) *V. pipistrellus*, Dobs., p. 223.
(7) *V. temminckii*, Dobs., p. 233, ♂ only.
(8) *Vespertilio nattereri*, Dobs., p. 307.
(9) *V. murinus*, Dobs., p. 309 (Lord Rothschild).
(10) *V. nigricans*, Dobs., p. 319 (Lord Rothschild).
(11) *Natulus stramineus*, Dobs., p. 342 (Lord Rothschild).

Emballonurinæ.

(12) *Taphozus perforatus*, Dobs., p. 383 (Lord Rothschild).
(13) *Cheiromeles torquatus*, Dobs., p. 405 (C. Hose, per Prof. Elliot Smith).
(14) *Molossus abrasus*, Dobs., p. 415, embryos only (purchased).
(15) *Nyctinomus gracilis*, Dobs., p. 436 (Lord Rothschild).

Phyllostomidæ.

(16) *Chilonycteris davyi*, Dobs., p. 453 (Lord Rothschild).
(17) *Brachyphylla cavernarum*, Dobs., p. 541 (Lord Rothschild); and female embryo (purchased).

M. Robin's list includes 37 species, which overlap with the types that I have examined in five instances only.

Reproduction.

It would seem obvious that, whatever obstacle the uropatagium may offer to normal quadrupedal copulation in the case of the Megacheiroptera, the impediment will be much increased in the Microcheiroptera, since, in the majority of them, this membrane is far more extensive. Further observation seems to be needed to settle the whole question. I have kept the two sexes of *V. noctula*, and some of the other common English bats, in captivity during their normal pairing season, but their unnatural surroundings appeared to preclude all manifestations of the sexual instinct. Duval, however, claims to have witnessed the act, and his account is best quoted in full. His observations were made in the spring, upon some Rhinolophids which had recently been captured. "La première fois je crus que le deux animaux se battaient, l'un d'eux reposant sur le plancher par sa région dorsal, et l'autre étant placé dessus, thorax contre thorax; je separai les deux individus, et, ayant saisi celui qui était dessus, j'interprétai facilement la véritable signification de l'acte en constatant l'état d'érection de son penis." If this be the normal method, it is certainly very strange, for it is remarkable that, whatever the actual details, the position of suspension should be departed from. It must not be overlooked that in accepting this description as a record of normal habits, one must take into account that the bats were unnaturally confined in a box, that the actual act cannot be said to have been witnessed, and that Duval was naturally predisposed to attach the most importance to what he saw, since he was endeavouring to prove that bats copulate in the spring, contrary to the opinions of most observers.

Concerning the reproductive history of the tropical and non-hybernating

Microcheiroptera there appears to be but little recorded: the observations of Gosse upon the habits of some West Indian bats seem to be unique.

Of the insectivorous bats inhabiting temperate regions, the details have been very thoroughly gathered together and woven into a complete history, thanks mostly to the outstanding work of MM. Rollinat and Trouessart. Concerning the Rhinolophid bats of France, and some of the members of the *Vespertilionidæ*, these observers have made a most interesting record of the breeding habits. Their observations were carried out upon some cave colonies of bats in various districts of central France (department of Indre) in 1896, and their conclusions may be given in the form of a brief summary, supplemented in places by additional observations culled from other sources.

Individuals apparently arrive at sexual maturity somewhat late in life, for breeding does not take place (with *Rhinolophus ferrum-equinum*, *R. hippsideros*, and *R. euryale*) until the second year at the earliest. Pairing takes place at the end of the summer season of activity. It is not till the first week of October that any spermatozoa are found in the genital tracts of the impregnated females; and only the mature second-year females taken at this time show signs of recent copulation.

During September a great change has been going on in the reproductive system of the males, and a marked enlargement of all parts of the system proceeds with great rapidity. The descended testes increase remarkably in size, and spermatozoa are liberated in enormous numbers. So great is the outpouring of spermatozoa at this time that the enlarged epididymis and vesiculæ seminales become filled, and a very remarkable overflow takes place into the bladder, causing a considerable deposit which separates from the urine. At copulation the spermatozoa are passed into the uterine cavity, and immediately there commences that activity of the glandular cervix which appears to be a universal concomitant of impregnation. In this case, however, the cervical secretion, possibly under the influence of the prostatic secretion in the seminal fluid, entirely plugs the female genital passages with a mucous "bouchon." The spermatozoa are sealed off inside the uterine cavity, and large numbers of them pass into the cornua; but their exit from the os uteri is effectively barred by the mucous plug which, becoming inspissated, forms a very intimate connection with the lining mucous membrane of the female genital tract. According to Rollinat and Trouessart, a somewhat similar plug forms about the orifice of the male genital ducts; but this male bouchon does not become so developed as does the vaginal bouchon of the female. When the formation of the bouchon is completed the animals suspend themselves in their winter retreats, and hybernate. Hybernation lasts throughout the winter months, and during

the whole of this time all metabolic processes are at their lowest ebb, and the spermatozoa within the uterine cavity appear to share in this lethargy, and the whole process of reproduction remains at a standstill.

In the early months of spring (in March in Indre) the bats again become active, and ovarian activity is manifested by enlargement and vascularisation of the female organs. Ovulation takes place towards the end of the month, and early in April the right uterine horn is obviously enlarged by a pregnancy.

As soon as fertilisation is effected by the waiting spermatozoa the bouchon liquefies, and shortly disappears. When pregnancy has started there is displayed a tendency for the females to segregate themselves. Among Rhinolophids the pregnant females associate in colonies, which also contain males and females in their first year, and even some males in their breeding year. In some other cases the only males found in such colonies are first-year males, and in the case of *Vespertilio murinus* not even these males are tolerated in the female camps. In some cave colonies studied by Duval the pregnant females remained isolated from the unimpregnated first-year females. There is apparently some sexual difference in habits brought about at this time, and there are several problems awaiting solution by the field naturalist. It would appear that the pregnant females not only isolate themselves in their retreats, but that they do not even fly in company with the males in the early part of the summer. It is not impossible that they choose some different period of the night for their activities. At this time of the year I have shot a series of over twenty *Vesperugo noctula* and larger numbers of *V. pipistrellus* in the early hours of the evening without ever obtaining a female. I have never succeeded in shooting a pregnant female of any species, although at the end of the summer young females, and females in which parturition has occurred during the year, are not so difficult to obtain in this way. The pregnancy, which commenced in the Rhinolophids during the first few days of April, is completed about the 20th of June or a few days later. The period of actual gestation is therefore about (*R. ferrum-equinum*) 80 days, which is a remarkably long one; while the interval between copulation and the termination of pregnancy is little short of nine months. A most interesting account of the parturition of a bat has been given by Mr H. A. Blake, the then Governor of the Bahamas. The species on which the observations were made was said to be new to science, and I do not know if a determination of it was ever published. The female was one of a cave colony into which shots were fired to obtain specimens. She was picked up among those that fell, and was found to be alive and uninjured. She was confined in a cage, and during next morning parturition commenced. The mother sus-

pended herself by one foot only, and used the other to assist the process of birth.

The membranes presented, and the left hind limb of the fœtus was the first part to be free of the maternal passages. The mother then used her free foot to rupture the membranes, and the liberated foot of the fœtus at once grasped the leg of the mother. Ten minues afterwards the other foot of the fœtus was extruded, and this also grasped the mother's free leg. In another five minutes the whole fœtus was entirely free of the maternal passages; it being born with its dorsal surface anterior. Directly it was born the mother lowered the young one with her leg, licked it all over, and placed it at the breast, while it was still tethered by its umbilical cord.

She bit through the cord, but carried out the process very slowly, not completing the severance till an hour after the young one was born. About ten hours after the birth of the young the placenta was extruded; the extrusion was assisted by the mother, and all the constituents of the afterbirth were eaten. It may be, considering the circumstances which led to the capture of this female, that the presentation was not a normal one; but I know of no other observations by which this may be checked. It would seem, however, that the ordered behaviour of the mother was natural enough.

The young bats are born with their eyes closed, and they remain blind for some considerable time. In the Rhinolophids the new-born young are clothed with fine hair, and the nose leaf already has its adult form; but the young of some species, such as *Vesperugo noctula*, are born quite naked, and hair is developed only at a later period. The milk dentition is present at birth. The nipple is seized at once in all species that have been observed; but in the Rhinolophids it is seized only for the purpose of actual suckling, for the inguinal anchoring nipples serve for mere fixation. The growth of the young is apparently fairly rapid, for *R. ferrum-equinum* is said to be nearly of adult size at the end of three months. In all the species that have been observed the young remain in the same colonies with their mothers, and hybernate in their company. There is evidence of a display of a rather noteworthy degree of maternal care in many species of which details have been recorded.

Reproductive System.

It has appeared to me to be useless to attempt a description of the reproductive system in those types that I have examined, basing the order of description upon the systematic position of the species. If this plan had been adopted it would have been possible, by combining my results with those of M. Robin, to give detailed descriptions of the internal genitalia of

some fifty species, but chaos would have been the keynote of such a series of descriptions. Within the limits of a family, and even within the limits of a genus, such very wide differences are found to exist in certain details of the anatomy of the reproductive system that all sense of order becomes lost in the endless contrasting and comparison of different forms. I have therefore attempted another plan, and if there is any reliance to be placed upon the features of the external genitalia as taxonomic criteria, the findings obtained by this method might suggest a starting-point for further work upon the order. The basis of the present description depends upon the fact that there are two very distinct types of female external genitalia present in the Microcheiroptera. Type I. is in most essential respects

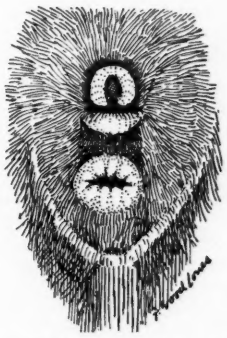

FIG. 1.—*Taphozus perforatus*. External genitalia of adult female. (An example of genitalia of Type I.)

similar to the condition seen in the Megacheiroptera. Type II. is absolutely distinct from that prevalent in that group.

These two types will therefore be treated separately, and the modifications seen within the limits of each type will be discussed so far as my own dissections and the published accounts will permit.

Type I.—The external genitalia of the female present as their most outstanding feature a transverse opening of the vulva such as is seen in the Megacheiroptera (and also in *Galeopithecus*). Combined with this feature, and obviously an essential part of the picture, is the abbreviation and flattening of the clitoris and its associated structures (see fig. 1). There is no well-marked Mons Veneris, and no apparent labia area. There is but poor differentiation of pubic hair, and usually there is some development of a post-anal or circum-anal fold. The external genitalia of the female of this type may be described as inconspicuous or little prominent. Combined

with this type of external genitalia very varying conditions of the internal genitalia are met with.

(*a*) The uteri may be as completely separated as in the Megacheiroptera: the whole tract consisting of long separate tubes and a short and septate uterine body, each uterus having its own separated os uteri. This condition is seen in *Taphozus melanopogon* (Robin).

(*b*) The very small corpus uteri may be septate, but the septum does not continue to the os uteri, which is single. An example of this arrangement is *Taphozus perforatus*.

(*c*) The uterine cornua are very long and lead into a very short median uterine body which is not septate. *Molossus abrasus*, and, according to Robin, *Rhynconycteris naso*, *Saccopterix plicata*, and *Emballonura nigrescens* are examples of this development. The genus *Nyctinomys* presents some variability in the extent of formation of the corpus uteri. In *N. gracilis* a short uterine body is present.

(*d*) The uterine horns may be about equal to the length of the corpus uteri, as in *Phylorrhina tridens*, *Rhinolophus* (Robin), and *Nycteris* with some specific differences (Robin).

(*e*) The corpus uteri may be longer and larger than the cornua in varying degree. This development of the corpus at the expense of the cornua reaches its maximum in some such stages as *Plecotus*, *Synotus*, *Vesperugo*, and certain *Vespertilionidæ*.

(*f*) Finally, in certain *Vespertilionidæ*, the cornua have practically disappeared and the uterus becomes a simple corpus uteri, merely showing traces of the presence of cornua at its angles.

Within the limits of the forms displaying this Type I. of the external genitalia there is therefore displayed the whole evolution of the uterus from the condition of two separated uteri to a perfectly simple uterus consisting solely of a median corpus and bilateral Fallopian tubes.

Type II.—The other type of external genitalia differs utterly from that just described (see fig. 2). The outstanding feature of this type is the antero-posterior elongation of the vulva, such as is seen (amongst other Mammals) in the Primates. Combined with this feature, and as a definite component element of it, is the elongation of the clitoris and its associated embryological structures. There is usually a well-marked Mons Veneris, and some indications of a labia area. As a rule there is a pronounced development of pubic hair. A post-anal or circum-anal fold is not conspicuously developed, and the external genitalia of the female of this type can only be described as prominent. So far as the material at my command goes, I have met with this type only among the *Phyllostomidæ*, and Robin, whose material embraced more forms, records the same finding. Combined with

this type of external genitalia there is but little variation displayed by the internal genitalia, the form of the uterus being practically constant. In *Chilonycteris davyi* the uterine body is produced into short cornua which are less than the uterine body in length, and, as is the rule with all bats, the right cornu exceeds the left in size. In *Desmodus* the uterus is cordiform (Robin), the cornua having been still further reduced; in *Artibeus* it is pyriform (Robin), and in *Brachyphylla cavernarum* it is in all respects like a human uterus in miniature.

The ovary in all is approximated to the sides of the uterus, and the Fallopian tubes make a rather tortuous course from the uterus to the spacious bursa ovarica.

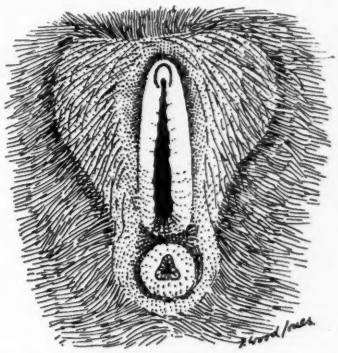

FIG. 2.—*Brachyphylla cavernarum.* External genitalia of adult female. (An example of genitalia of Type II.)

According to Dobson, *Noctilio* and its immediate allies show characters of this Type II. in so far as the vulval orifice is elongated in the antero-posterior direction. Certainly the genitalia of *Noctilio leporinus* as described by Robin differ somewhat widely from the condition seen in other *Emballonuridæ*, but according to this author the vulval orifice is in reality transverse and the unusual appearance is due to the elongation (instead of the usual flattening) of the clitoris. The *Noctilio* group is an extremely interesting one, and there are evidently a great many structural details in which it allies itself with the *Phyllostomidæ*, and especially with *Chilonycteris*. So far the opportunity of making a detailed study of the genitalia has not occurred. I am therefore uncertain which interpretation, that of Dobson or that of Robin, is the correct one.

Another candidate for Phyllostomid rank is the genus *Natulus*, and the claim is made on the strength of embryological evidence put forward by

Harrison Allen. There are apparently some characters of the embryo of *Natulus stramineus* which appear to point in the direction of such an alliance. In the adult female the clitoris is certainly elongated, but the

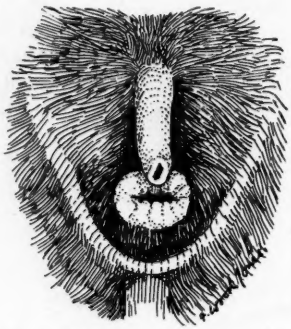

FIG. 3.—*Taphozus perforatus*. External genitalia of adult male.

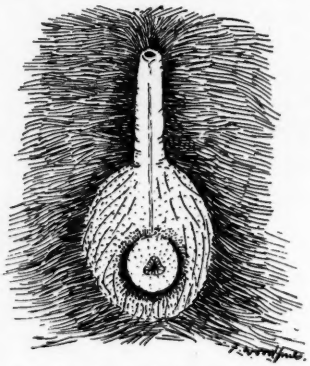

FIG. 4.—*Brachyphylla cavernarum*. External genitalia of adult male.

other characters of the genitalia seem to be in harmony with the conditions seen in Type I. The vaginal orifice is rounded, but inclines more to the transverse type; the uterus is bicornuate. In the male the most remark-

FIG. 5.—Male of *Vesperugo temminckii* during the breeding season, showing the enormous proportions of the descended genital glands at this time.

able feature is the elongation and tapering form of the penis. These characters possibly have some relation to the enormously enlarged uropatagium, and on the whole *Natulus* seems to range itself most naturally with the forms which fall under the first type of genitalia.

Male.—In the male the form of the external genitalia is almost identical in the two types. Illustration is made of *Taphozus perforatus* (fig. 3) and of *Brachyphylla cavernarum* (fig. 4), and further description is not needed in detail. In *Taphozus* (as an example of Type I.) the post-anal pouch seen in *Galeopithecus* and in the Megacheiroptera is well marked, and traces of it are present in the males of most Microcheiroptera of this type. In *Brachyphylla* (Type II.) and other Phyllostomids it is not nearly so well developed. The glans penis in all contains an elongated ossicle, and therein the Microcheiroptera differ from all the Megacheiroptera with the exception of *Harpyia* (Dobson). The internal genitalia of the males, however, show

FIG. 6.—*Vesperugo serotinus.* External genitalia of an adult male.

well-marked distinctions which separate them sharply into the same two types as are indicated by the external genitalia of the female. In Type I. the vesiculæ seminales are large and complex, while in Type II. they are reduced and simple. In Type I. the prostate has, as a rule, an anterior portion, and it usually surrounds the urethra with a ring of glandular tissue; in Type II. the prostate, though well developed, is confined to the back of the urethra. The descensus of the testes is periodic in all forms, and during the breeding season the descended organs reach to remarkable dimensions when compared to the body size of some of the very diminutive species. The condition in *Vesperugo temminckii* is illustrated from specimens shot on the wing during the breeding season in Nubia (see fig. 5). The site of the scrotal area varies. In many species of Type I. the scrotum is

post-anal, and this condition is figured as it occurs in *Vesperugo serotinus* (see fig. 6). A post-anal scrotum does not occur in any members of the Phyllostomids of which I have accounts or specimens.

Embryonic Stages.

The developmental stages, in such embryos as I have been able to obtain, leave no doubt that the evolution of the genitalia follows the lines of the

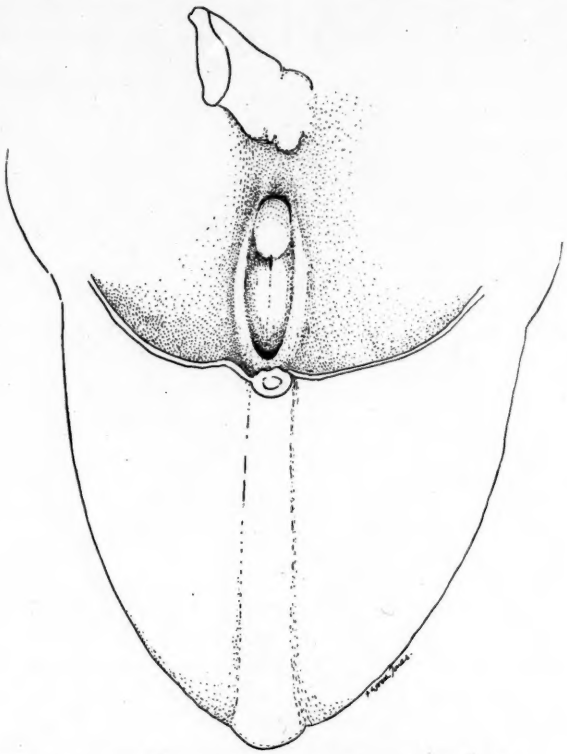

Fig. 7.—*Plecotus auritus*. External genitalia of a male embryo of 9 mm. reconstructed from serial sections.

cloaca explicata, and is effected by outfolding of the cloaca upon the surface of the body, the circum-anal or retro-anal pouch being a remnant of the cloacal margin. The phase seen in a 9-mm. male embryo of *Plecotus auritus* may serve to illustrate this point (see fig. 7). In the male

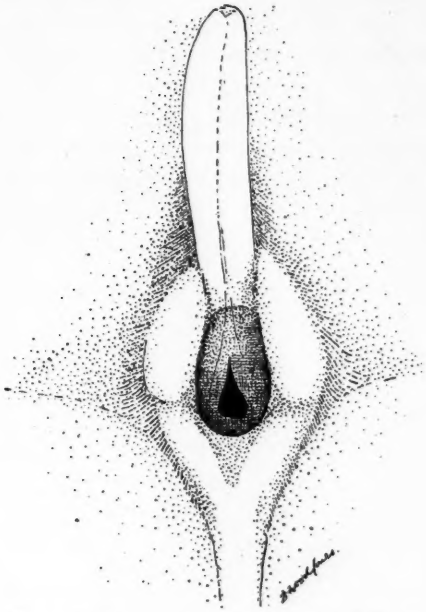

FIG. 8.—*Molossus abrasus.* External genitalia of a male embryo of 28 mm.

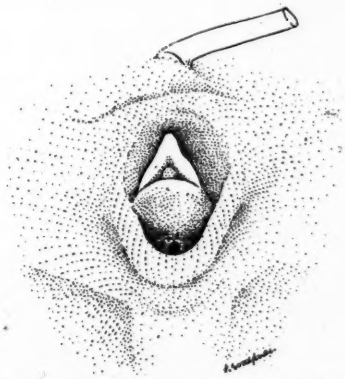

FIG. 9.—*Molossus abrasus.* External genitalia of a female embryo of 24 mm.

embryo of *Molossus abrasus* of 28 mm. the scrotal site in the cloacal margins is already well defined (see fig. 8).

In the case of the females the characters of the external genitalia, peculiar to the two types described are displayed early.

In the female embryo of *Molossus abrasus* of 24 mm. (see fig. 9) the

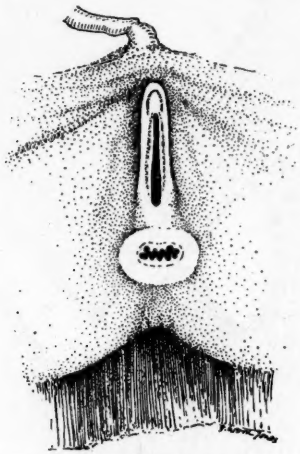

FIG. 10.—*Brachyphylla cavernarum*. External genitalia of a female embryo of 32 mm.

flattened clitoris has already assumed the form so typical of *Galeopithecus* and the Megacheiroptera, and the cloacal margins are still distinctly marked. The embryo of *Brachyphylla cavernarum* is more nearly mature (32 mm.), and in it all the characters of the adult are fully determined (see fig. 10).

MAMMARY GLANDS.

In all the Microcheiroptera there is a pair of pectoral mammary glands, situated rather laterally upon the enormously broadened chest, and having a very considerable extension of gland tissue upon the dorsal aspect of the trunk. During the time of suckling the whole gland and the nipples are extremely prominent, and the nipples towards the end of the nursing period are usually much elongated. The condition of the adult functional gland is illustrated in *Brachyphylla cavernarum* (see fig. 11).

In the Rhinolophid bats there is an additional pair of nipples situated in the inguinal region. These are, as Rollinat and Trouessart described

them, "faux tétons du pubis, faux tétons qui ne sont que des organes de fixation à la disposition du nouveau-né, mais ne lui servent pas à se nourrir car ils ne communiquent avec aucune glande." Elsewhere I have alluded to nipples of this class as "anchoring nipples," since such a term describes

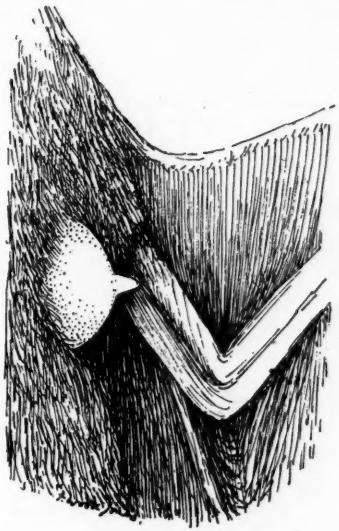

FIG. 11.

their function. These anchoring nipples do not seem to be met with outside the limits of Rhinolophids.

PELVIC SYMPHYSIS.

According to Dobson, a ventral meeting of the two sides of the pelvis occurs only in the *Rhinolophidæ*, and this statement appears to be substantiated by the accounts of other authors. So far as my material goes, I have met with it only in *Phyllorhina tridens*, where in both sexes a very short symphysis is present.

In the males of some other species the gap between the two pubic bones appears to be somewhat less than in the females, but even in them a true symphysis does not occur. In *Brachyphylla* the separation in both sexes is extremely wide. This limited distribution of a symphysis pubis in the Microcheiroptera is of the greatest interest, since it is only in those forms in which it is present that any urogenital sinus is found.

In Rhinolophids, where the female symphysis is slightly developed, "le méat urinaire est situé très près de l'extrémité du vagin" (Robin p. 146). In *Phyllorhina tridens* (and, according to Robin, in *P. commersonii*, *P. diadema*, and *P. armigera*) the urogenital sinus is well developed in harmony with the more elongated symphysis. In no other genera is there a urogenital sinus, for the urethra opens directly into the vulval orifice. The Microcheiroptera therefore furnish a good example of symphyseal development, with the presence of a female channel which is common to the urinary and genital systems.

Placentation.

In all the species of which I have had the opportunity of examining the fœtus, and all save one of those described by Robin, the placenta is discoidal. Robin has met with but one exception, and that is in the case of *Miniopterus schreibersii*, in which the placenta is double. Although he likens this to the well-known condition seen among the Primates, there appear to be several important differences, and he himself sums up the situation by saying, "le dédoublement du placenta est un caractère d'ordre secondaire et du peu d'importance au point de vue taxonomique." Harrison Allen has described the embryonic forms of many species, but does not deal with the question of the placentation.

Summary and Conclusions.

In a general way the outlines of the genital condition of the Microcheiroptera are clear enough: there has been complete outfolding of the cloaca in all forms. It is only when pressed to an explanation of the varying details seen in the very large number of species that difficulty is encountered. That, judged by the characters of the genitalia, there are two main types embraced within the limits of the group is quite obvious. But it is difficult to know what value to attach to these types in the absence of a very great number of details regarding many species concerning which there is some degree of uncertainty.

It might be suggested that we are dealing with a group which is not truly monophylic, and that more than one primitive mammalian stock may have produced flying members, the finished individuals, derived from whatever stock, having become extraordinarily similar in their general forms by a process of convergent specialisation to their very peculiar mode of life. It is, of course, not impossible, despite the apparent inherent improbability, that this is the actual case. The Phyllostomids may

represent the terminal products of a stock which became "bats" in the neotropical region, while the rest of the Microcheiroptera evolved on similar lines, but maybe from a different stock in other parts of the world. The geological record does not assist in confirming or reputing such a supposition. A great deal more work remains to be done in studying the structural details of the group before comparative anatomy can decide the question, and it is impossible to avoid the conclusion that if a tithe of the work that has been lavished on the study of preserved skins and dried skulls had been expended upon investigations with scalpel and forceps, the problem would not now be open for solution. Concerning the zoological position of the two types there can be no doubt, for the Phyllostomids are obviously more Primate-like, or higher, than are the other Microcheiroptera. Indeed it might almost seem that this family had taken to an aerial life after a fair proto-Primate apprenticeship had been served, whereas the remaining members of the group may have had a much more lowly origin.

Connecting forms, not hitherto examined in sufficient detail, may be found uniting the two types and pointing to the Phyllostomids as being the highest evolution within a monophylic group. Or the group may prove not to be a monophylic one, as the work of comparative anatomists upon other systems and organs has hinted, and certainly this study of the genitalia, limited as it is, points in the same direction.

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A NOTE ON THE RETINACULA OF WEITBRECHT.

By THOMAS WALMSLEY, M.B., *Senior Demonstrator in Anatomy, University of Glasgow.*

THE synovial membrane of the hip-joint is in extent and attachment similar to that of other diarthroses, but the retinacula of Weitbrecht (or ligaments of Stanley) lend to it a special interest. These retinacula are readily recognised on the interior of the capsule as flattened bands passing inwards towards the margin of the head of the femur from the attachment of the peripheral capsule. The following description of their constitution may be selected as expressive of current opinion. The retinacula are arranged in three groups, superior, middle, and inferior: structurally, they are synovial covered capsular reflections: morphologically, the inferior set is said to represent the persistent retinaculum of the invaginated ligamentum teres (Keith), while the superior set has been described by Frazer as being entirely due to medially directed reflections of the tendon of the M. pyriformis: functionally, they are developed either to prevent intracapsular fracture of the neck of the femur in the infant (Fawcett) or, if that has already occurred, as a means of fixation of the fragments (Hepburn in Cunningham). These descriptions form the bases of this study of these bands.

The blood-vessels which perforate the capsular attachment and pass along the superficies of the neck of the femur to enter the foramina towards the articular margin of the head may be shown by X-ray photographs of mercury-injected specimens to terminate in the metaphysis of the neck and the epiphysis of the head. From the points where they perforate the capsule these vessels derive and carry inwards indefinite fibrous prolongations of the capsule wall which are covered over or are completely invested by reflections of synovial membrane. These elements constitute the retinacula of Weitbrecht. The fibrous prolongations terminate by fusion with the superficial structures of the neck at varying and indefinite distances from their origin, while the synovial reflections pass onwards to the cartilaginous margin of the head where they form the coverings of the "synovial pads of fat." In Haver's definition the term synovial pad is applied to a mass of vascularised fat invested by synovial membrane locally modified for the production of synovia. In addition, however, to the glandular function of the covering membrane,

these masses act as movable pads, which are drawn into and occupy the more obvious peripheral spaces which would otherwise occur between the articular surfaces of organic joints during their action.

This separation of the articular surfaces, as I shall show in a forthcoming publication, is peculiar to organic joints, and to fill the potential intervals movable and yielding structures are required: and such are found in two modifications (Goodsir). If space alone is to be occupied synovial pads fulfil the requirements, and associated with each pad is a synovial mechanism for the regulation of its movements; but if resistance to pressure is an additional function fibrocartilaginous tissue is necessary.

In connection with the hip-joint there are three synovial pads: two are in relation to the articular margin of the head of the femur, and the third is situated in the acetabular fossa. The femoral pads are placed in the superior and inferior concavities of the articular margin of the head at the medial ends of the synovial retinacula. Both are freely movable on the underlying tissues of the neck, so that on semi-flexion of the limb, when the whole peripheral capsule, and therefore the synovial retinacula, are relaxed, these pads react to the suction action generated in the joint within the cotyloid ligament, and move so that the inferior comes to lie on the pubic portion of the acetabular margin and occupies an interval which would otherwise be created between that part of the acetabular surface and the femoral neck adjacent to the receding margin of the head. When the inferior retinacula are stretched, as occurs in the tightening of the capsule in extension or hyperflexion, they pull on the synovial pad and flattening it on the neck of the bone remove it from any possible intervention between the articular surface of the acetabulum and the advancing margin of the femoral head. These pads, then, are placed so as to equalise the uneven articular margin of the head of the femur in its varying position on the uniform margin of the acetabulum, and their synovial mechanisms are the retinacula of Weitbrecht. The acetabular pad is placed in the acetabular fossa superficial to its thin easily detached periosteum, to which it is movably united by weak ligamentous connections and fine vascular channels. The amount of the mass varies in individual cases and may here and there seem to be deficient, especially in the upper part of the fossa, but normally is of volume more than sufficient to fill the acetabular fossa, the excess being necessary in its function. The movements of this pad are such that on semi-flexion of the limb it passes into the acetabulum under the action of the suction force within the joint and controlled by the synovial covering of the lig. teres, and abolishes the interval which would otherwise be produced by the apical displacement of the head of the femur: and this movement is visible from the peripheral aspect of the joint as an

"indrawing" of the structures superficial to the "acetabular gap." On extension of the limb the excessive portion of the pad is visibly protruded through the acetabular gap, and reaches that position not by an expulsive action of the advancing apical part of the femoral head but by being actively withdrawn by its peculiar synovial retinaculum attached to the superficial part of the lig. teres.

The suction action generated within the joint is entirely within the cotyloid ligament, and is obtained because of the atmospheric vacuum within that part of the articulation in which the joint surfaces undergo separation from one another. Between the articular surfaces, however, there will be at no time any interval unoccupied by synovial fluid or unobliterated by the movable walls of the containing cavity or of the contained femoral head, since the induction of a vacuum interval by separation of the surfaces would determine the onset of a force active in the re-establishment of surface contact, but detrimental, since in direct opposition, to the working of the contracting muscles. In the lateral movement of the head of the femur which accompanies its rotation to semi-flexion from the extended position the apical interval is avoided by the movement of the acetabular pad, which falls into the acetabulum and diminishes its cubic content. The cotyloid ligament, on the other hand, is expanded by the lateral movement of the head and thus the volume of the cavity is increased, but the movements of the femoral pads avoid the appearance of any marginal interval.

We have determined these facts in the adult human subject, and after consideration of the retinacula in some of the domestic carnivora,[1] certain of the ungulata,[1] and in one of the apes, feel that the following conclusions are justified: That the incidence of the retinacula is coincident with the blood-vessels of the epiphysis of the head and metaphysis of the neck as determined by dissection of the recent specimen or by analysis of the vascular foramina in the macerated bone: that they are reflections of the synovial membrane over the fibrous sheaths of these vessels, and the sheaths are indefinite prolongations of the capsule wall: that they serve as an active mechanism in the function of the femoral synovial pads. Further, we would believe that none of them possesses any peculiar morphological significance, but that they are developed and are retained permanently where they will be free from direct capsular pressure and are associated with the blood-vessels and synovial pads purposively and precisely in those situations.

In denying the morphological significance of the inferior retinaculum it

[1] In these groups there is no superior retinaculum, nor superior femoral synovial pad, owing to the shape and articular incidence of that area of the femoral head.

seems reasonable to conclude that the view advanced by Keith is in itself insufficient to account for the persistent retention of a structure, of importance only at so remote a stage in phylogeny: nor is it in agreement with the facts of comparative embryology. In the human embryo the lig. teres is completely free at the first appearance of the joint cleft: in the embryo tapir a synovial mesentery binds the ligament *to the capsule wall*, while in the adult the ligament is invested as in the human subject (Welcher): in the walrus, where the limb pertains to the reptilian type, the ligament arises within the joint cavity permanently enfolded in a synovial reflection *from the capsule* (Moser). We believe these facts to indicate that the inferior femoral retinaculum does not represent, in whole at least, the persistent remains of the mesentery of the invaginated lig. teres, but that this mesentery would, and possibly does occur, as the retinaculum of the acetabular pad of fat (also described by Weitbrecht) which arises in relation to the extra-acetabular part of the lig. teres and invests the blood-vessels passing through the acetabular gap to the acetabular synovial pad. As regards the superior group being the direct prolongation of the tendon of the M. pyriformis, we believe this to be the seeming result of the fusion of that tendinous expansion with the capsule, and that it is from the capsule that the fibrous elements of the retinaculum are derived. In the majority of mammalian groups (of all we have examined) the superior retinaculum is absent, and this we have associated with the shape of the articular femoral head.

In the infant the retinacula are of relatively larger size than in the adult, and we would relate the fact to the relatively larger blood-vessels which pass to the head at that period.

A CASE OF CONGENITAL ATRESIA OF THE ILEUM.

By Cecil P. G. Wakeley, M.R.C.S. Eng., L.R.C.P. Lond., *House Surgeon, King's College Hospital; Assistant Demonstrator of Anatomy at King's College, London.*

The specimen described in this paper occurred in a female full-term child, which was brought to King's College Hospital on the second day after birth with symptoms of obstruction. The signs pointing to obstruction of the small intestine, the child was operated upon at midnight the same day, an exploratory laparotomy being performed through the upper part of the right rectus muscle. The stomach and proximal part of the small intestine were found to be enormously distended and antiperistalsis could be plainly seen. There was a marked narrowing of the intestine in the upper part of the ileum (fig. 1). The rest of the small intestine beyond the constriction was very small and received its blood supply from a pedicle of mesentery, in which the vessels were dilated and thrombosed. The cæcum and the rest of the large intestine were normal.

As regards treatment, a gastro-enterostomy was contra-indicated on account of the rest of the small intestine having a defective blood supply, its vessels being thrombosed. It would have been useless to have performed a jejunostomy, because the child could not have lived with merely a stomach and at most 20 inches of small intestine; and, besides this, the condition of the jejunum was very bad, it was almost black in colour and covered with flakes of coagulated lymph. Having carefully considered these points, I very reluctantly replaced the intestine and closed the wound. The child died eight hours after the operation.

At the post-mortem examination no other congenital defects were found.

On making a more detailed examination later it was found that the distended part of the gut above the constriction contained meconium. The distal part of the ileum and large intestine were empty. The mesentery opposite the constriction and the part of the intestine beyond this contained numerous enlarged lymphatic glands and the veins were thrombosed. The atresia extended for a distance of about 2 cm. and the greatest diameter here was less than 4 mm.

A transverse section (fig. 2) through the middle of the imperforate part

showed that the lumen was blocked by a loose tissue consisting in the centre of detached extremities of the villi and fibrinous strands, external

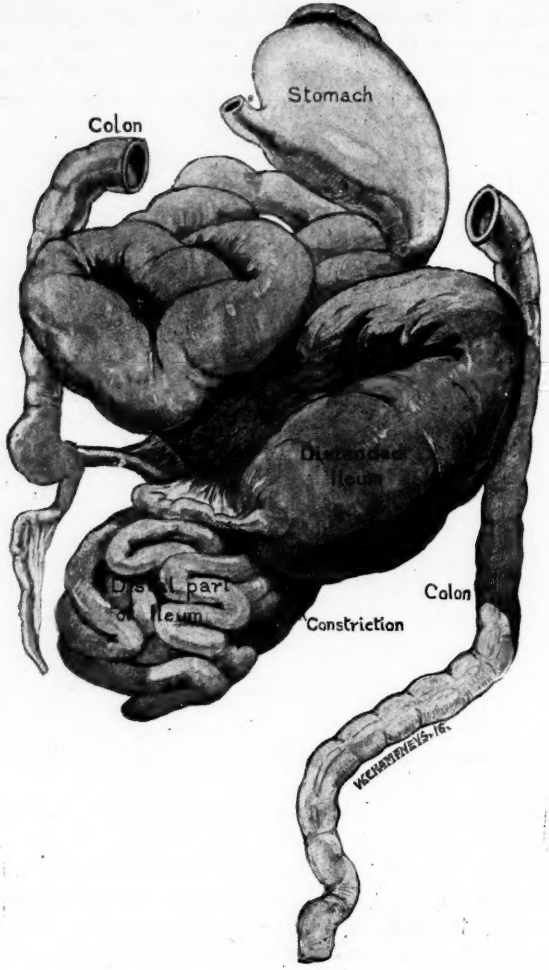

FIG. 1.—Atresia of ileum.

to this was an intermediate zone of connective tissue, continuous with the interglandular tissue surrounding the basis of Lieberkühn's glands. These

lay in the third or outer zone. In the intermediate zone the epithelium had degenerated, and was replaced by a granular material and fibrinous bands.

A drawing of a somewhat similar case was kindly sent by Professor P. Thompson for exhibition with my own specimen. The imperforate part of the intestine in his case was, however, much nearer the ileo-cæcal valve, and the intestine was reduced to a fibrous cord running along the free

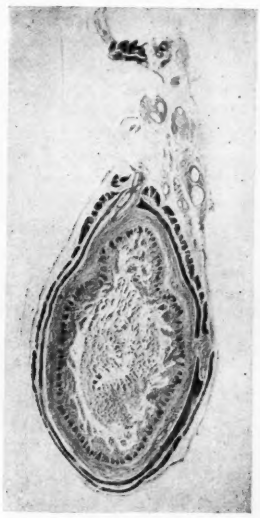

FIG. 2.—Transverse section through imperforate part of ileum showing thrombosed vessels in the mesentery.

border of the mesentery and joining the proximal and distal parts of the intestine.

The interest of these cases lies principally in the possibility of saving life by intestinal anastomosis. Quite recently N. P. Ernst of Copenhagen has published (1) a case in which he succeeded in saving the life of a child by performing a duodeno-enterostomy for an atresia situated below the papilla of Vater. He brought a coil of jejunum 4 inches from the duodeno-jejunal flexure upwards in front of the transverse colon, and united it to the duodenum close to the hepatic flexure.

Another successful case was reported by P. Flockens (2), where atresia was present between the middle and lower thirds of the small intestine. The bowel was reduced to a fibrous cord, at the free edge of the mesentery,

which united the blind ends of the bowel. An entero-entero-anastomosis was performed, and the child made a complete recovery.

As regards the etiology of these cases there appears to be no very satisfactory explanation of the cause of the atresia. The view most commonly held is that of Tandler (3) and afterwards confirmed by Forssner (4), viz. that the normal more or less complete obliteration of the lumen of the tube, by proliferation of the intestinal epithelium, persists. This proliferation occurs in human embryos between 5 and 30 mm., and is most marked in the duodenal region. Moreover, it is stated that the gut fails to expand owing to pressure exerted by the mesodermal wall on the enclosed epithelial cord.

Professor Kreuter, on the other hand, though agreeing in certain points with the former, believes that the epithelium degenerates in places, and that here and there rounded cells from the mesodermic wall penetrate it, and thus reach the surface of the mucous membrane and eventually lead to occlusion.

Some cases appear to be due to constrictions from without by bands, while others appear to be associated with twists and bends of the gut, *e.g.* those at the proximal and distal flexures of the umbilical loop of the intestine.

Professor P. Thompson suggests that in his specimen, the atresia lying within the sphere of influence of the vitelline duct, it may have arisen when the duct was separated from the summit of the intestinal loop at the end of the first month.

My specimen and others, in which a considerable length of the intestine is imperforate, suggest that a twist or blocking of the mesenteric vessels resulting in a defective blood supply of part of the intestine may in some cases be the immediate cause of the arrest in its development.

In conclusion, I should like to offer my best thanks to Dr R. J. Gladstone for so kindly helping me with the dissection of the specimen and showing it, in my absence, at the meeting of the Anatomical Society.

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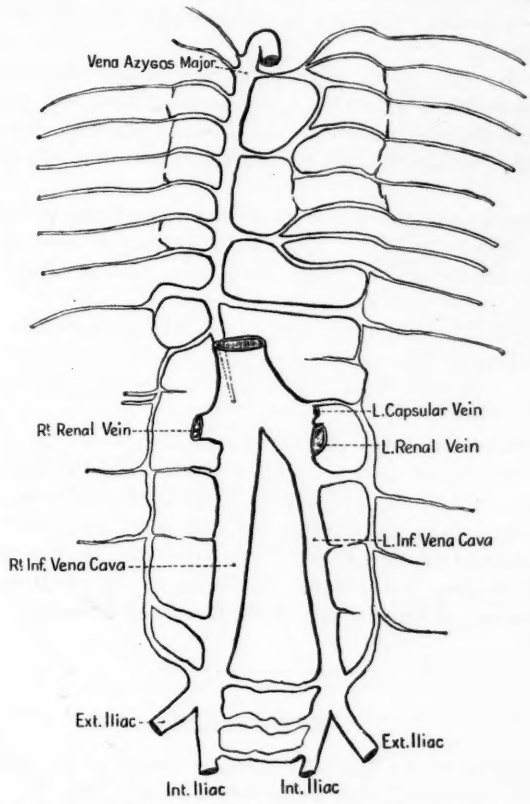
A CASE OF DOUBLE INFERIOR VENA CAVA.

By M. F. Lucas, M.B., B.S., *Lecturer on Embryology, The London School of Medicine for Women.*

The accompanying diagram illustrates the arrangement of veins on the posterior wall of the trunk of a male subject, æt. 70, dissected in the



A case of double inferior vena cava.

anatomical department during the present session. The vena cava is double below the entrance of the renal vessels, the left inferior vena cava

joining the right by a very large connecting trunk at the level of the second lumbar vertebra. The right and left inferior venæ cavæ lie on the anterior aspect of the bodies of the lumbar vertebræ and terminate below in right and left internal and external iliacs, the tributaries of which are quite normal. The vena azygos major on the right side, and the anastomotic loops (venæ azygos minores) on the left side, lie on the bodies of the thoracic vertebræ in a corresponding position to that occupied by the inferior venæ cavæ. The vena azygos major, besides communicating below with the right ascending lumbar veins, also opens into the undivided portion of the inferior vena cava on its posterior surface. The lumbar veins arise from bilateral vessels (of considerable size on the right side) which run vertically on a line joining the roots of the transverse processes of the lumbar vertebræ, and communicate below with the inferior venæ cavæ and above with the venæ azygos. There are a few small veins connecting adjacent intercostal veins across the heads of the ribs, and these are in line with the large vertical veins found in the lumbar region. The symmetrical arrangement of the whole anomalous system of veins is particularly striking.

ON THE PROPORTIONS AND CHARACTERISTICS OF THE MODERN ENGLISH CLAVICLE.

By F. G. Parsons, *Professor of Anatomy in the University of London.*

The investigations with which this paper is concerned have gradually grown out of the desire to know whether we could form any idea of the shoulder breadth and physique of prehistoric races from a study of their clavicles in the same way that we estimate their height and the muscularity of their lower limbs from their femurs. I was also anxious to know whether the clavicle is of any use in the difficult matter of sexing a skeleton.

I was more happy in clavicular than in femoral measurements, because I was able to examine the bones of 103 males and 80 females, of whose age and sex I was absolutely certain; while in the case of the femur investigators have to content themselves with a few senile bones of known sex or else to guess the sex in a large mass of doubtful bones and then to deduce sex characteristics from the bones thus arbitrarily sexed.

The people on whom these clavicular measurements were made belonged to the English lower and lower-middle classes. They were all full grown, and their average age was 44 years. None were under 18 years, and all cases in which the bones were diseased or the body deformed were excluded.

In the first place the shoulder width was taken with a large sliding scale specially made for the purpose.

At first I took the biacromial breadth recommended in the anthropological text-books, but after using it for some time on both the living and dead subject, I came to the conclusion that it is a thoroughly unpractical and unreliable measurement except in the thinnest bodies.

I have found competent observers differing by two, three, or more centimetres in this measurement, and I have made as great differences myself in remeasuring the same body after a short interval; in fact, I was so disappointed that I left off taking it and contented myself with measuring the shoulder width at the upper part of the deltoid. I know, of course, that the width here depends a good deal on the fatness and muscularity of the body, but it is a measurement on which different observers

can agree and, when a large enough number of cases is taken, a much more reliable average established.

I find that, after measuring the biacromial and the total shoulder width of 73 living adults, the total width at the upper part of the deltoid averages 35 mm. more than the biacromial in 21 males and 28 mm. more than the biacromial in 52 females. The total averages were:

	Biacromial.	Total Width.
21 ♂ . .	379 mm.	414 mm.
52 ♀ . .	348 „	376 „

These measurements were taken from young adults at St Thomas's Hospital and the London School of Medicine for Women.

I found it easier to determine the biacromial measurement in living than in dead subjects, but even then it was necessary to take the mean of three separate attempts at measurement in many cases.

My first point, then, was to see what proportion the length of a clavicle bears to the width across the shoulders at the upper part of the deltoid, and here I was at once confronted with the difficulty that the two clavicles are seldom the same length, for 83 left male clavicles gave me an average clavicular length of 153 mm., while 70 right male bones averaged 151 mm. In the females, on the other hand, I found that 64 left and 65 right bones both gave me an average of 138 mm.

But, of course, many of these measurements were made on people from whom I had only been able to secure one clavicle, so I decided to check them with 50 males and 50 females in whom the clavicles of both sides were available. The result of this was that in 50 males the left clavicle averaged 154 mm. and the right 152 mm., while in 50 females the average was 139 mm. on the left and 138 mm. on the right.

I therefore believe that the left bone averages one to two millimetres more than the right in length, but I do not think that this is likely to make any great practical difference in working out the proportion of the shoulder width.

For instance, by dividing the shoulder width into the clavicular length $\times 1000$, I found that with 50 male bodies in which both clavicles were present, the left clavicle averaged ·387 of the shoulder width, while the right averaged ·382. In 49 female bodies with both clavicles available, the left averaged ·383 and the right ·380.

To take a concrete example, let us pick out at random No. 58 from the left female clavicles. The clavicular length of this is 134 mm., and if this is divided by ·383, the average proportion for left female clavicles, we should estimate that the possessor of the bone had a shoulder width of

about 35 cm., while, as a matter of fact, she was 34·1 cm. across the shoulders. This, I think, is as near as we have any right to expect to get in practice when we consider the many disturbing influences at work; for this particular individual might have been fat or lean, muscular or attenuated, while the left clavicle, which we are supposing the only clue given us, might in this particular case have been a good deal shorter or a good deal longer than its fellow. I submit that if from a clavicle we can deduce the actual shoulder width of an individual to within a centimetre or two, we are distinctly adding to our power of reconstructing the whole contour of the body from a part.

Of course I am far from claiming that what is true for modern English people must be true for all races, but we can only advance a little at a time and that with great labour.

We have seen that in both sexes the left clavicle seems to average a little more than the right. Is this in spite or because of the fact that the right arm is used more constantly than the left? Unfortunately, I have no means of knowing which of the possessors of the clavicles were left-handed, but I can think of two possible ways in which increased use of a clavicle might lead to shortening: firstly, that it might increase the curvature and thus bring the two ends nearer; and secondly, that it might lead to an earlier bony union of the epiphyses, which would stop further growth. Both these points will be investigated later; but for the present I shall content myself with recording that out of 100 individuals in whom the length of both clavicles was available, the left was the longer in 54 per cent., the right in 34 per cent., while in 12 per cent. the length on the two sides was equal. That the longer clavicle is so comparatively often on the right side makes it unlikely that left-handedness is the cause or, at any rate, the only cause. I would further record that while the left bone averages 2 mm. more in length than the right, the differences between the two may be as much as 9 mm.

It is the occasional presence of these extreme cases that makes it desirable, whenever the chance occurs, to take the mean length of the two clavicles and to divide it by the mean proportion of the clavicle to the shoulder width on the two sides. Even by this method considerable error may arise in individual cases, errors of 3 cm. or even more, though this, of course, would be expected by anyone who realises the great difference which a plentiful supply of subcutaneous fat makes in the breadth of the shoulders; but when a series of ten cases is available the average, for practical purposes, is always reached.

If it is thought advisable to apply the ratio to a single skeleton, it must be understood that the result will be an approach to the actual

shoulder width during life, presuming that the individual was moderately supplied with fat and muscle.

The Curvature of the Clavicle.

After taking the clavicular length and finding its proportion to the shoulder width, I sought a method of estimating the curvature of the clavicle, and at last adopted the following plan.

An accurate contour of the clavicle from above is drawn with the dioptograph, but before this can be done it is necessary to be sure that the bone is properly orientated, and it should be noticed in doing this that the facet for the first rib is not directly below the sternal end but lies below and in front. There is generally a small tubercle for the sterno-mastoid muscle directly above the sternal end, and this I found very useful; but, failing this, as long as the anterior and posterior borders

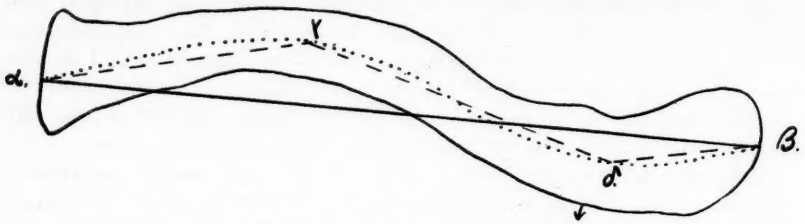


Fig. 1.—Method of estimating the curvature of a clavicle.

of the acromial third of the bone are in the same horizontal plane, the clavicle is very nearly in the living position.

When the contour has been drawn the central points of the sternal and acromial ends (α and β, fig. 1) are joined by a straight line, and then the central axis of the bone is drawn as a curved line which is always half-way between the anterior and posterior borders.

The points of greatest anterior and posterior convexity (γ and δ) are then fixed on the curved line, and the four points α, γ, δ, β are joined by straight lines.

In this way two angles are described—an inner one (α, γ, δ), open backwards; and an outer one (γ, δ, β), open forwards. When the size of each of these has been taken by means of a protractor and the two added together, the sum will be the index of curvature; though, of course, the lower the index the more curved is the clavicle and vice versa.

The figures obtained in this way give me the following results:—

In 83 male left clavicles the average index of curvature is 301, while in 70 right males it is the same; but when the corresponding bones of

opposite sides of fifty males are taken the left index is 300 and the right 301. In the same way the average index of 64 left female bones is 306 and of 65 right female bones 305; but when fifty actual pairs of bones are dealt with the left is 305 and the right 304.

There is therefore pretty definite evidence that the male bones are more curved than the female, while in both sexes the right bone is a little more curved than the left.

As the difference in the curvature between the two sides only amounts to 1°, it does not look as if it could account for the greater length of the left clavicle; but, in order to test the matter further, I picked out the fourteen cases in which the left bone was 5 or more than 5 mm. longer than the right and added up the indices of curvature, but to my surprise the right bones in these individuals were, on the average, slightly less curved than the left.

A similar experiment on the 12 females in which the left bone was more than 3 mm. longer than the right showed that the right bone was more bent than the left to the extent of an average of 4°. I do not dare to lay any stress on this last, while the result of the male bones is so different, and I cannot think that the greater length of the left clavicle is to be accounted for by the greater curvature of the right.

A casual inspection of a number of clavicles gave me the impression that the bones of old people were more curved than those of young; but on picking out the 25 left male clavicles from subjects between 18 and 35 years of age I find that the average curvature is 300, while the average for all ages is, as we have seen, 301. If, therefore, there is a slight difference, it is evidently so slight as to be of no practical value in determining the age of bones.

The Average Contour of the Clavicle.

The measurements which follow in the tables have been planned with the object of enabling a diagram to be drawn of an average modern English clavicle, of both sexes, from above and from in front.

By putting these together a model of such a clavicle may be constructed, and this may serve as a standard of comparison with those of other people.

Having determined the length and degree of curvature of the clavicle, the next thing is to note the position of the points of maximal curvature. This is done by recording the lengths of the three segments $\alpha\gamma$, $\gamma\delta$, and $\delta\beta$ (fig. 1), which are spoken of in the tables as inner, middle, and outer segments.

When these are known it is possible to draw the framework of a

single clavicle or, as in fig. 2, of the average of a series. The next step in the reconstruction of the average clavicle is to put in the central axis as a curved line with its maximal convexities at γ and δ, and on this the contour of the bone may be built up if its width at certain points is known.

I have contented myself with taking the width at five places, and with these I find that a very accurate reconstruction of an individual clavicle is possible; but it is clear that the more measurements there are the greater will be the accuracy and the less left to the fancy of the draughtsman.

The first width (see fig. 3) is that of the inner extremity, and it, like all the other widths, was measured on the dioptographic tracing with a steel tape and then on the actual bone with calipers, thus checking the tracing for this and other purposes.

In the left female clavicles the average measurement is 21 mm.

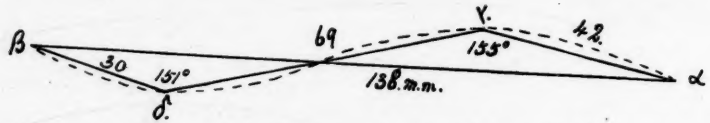


Fig. 2.—Framework for reconstruction of 64 left female clavicles.

The second width is at the inner angle and is 11 mm.

The third width is taken wherever the bone happens to be narrowest, and, in order to fix its average position, its distance from the point a along the line $a\beta$ has to be ascertained. This average distance in the particular group of female bones under study is 52 mm., but its range of variation is very great and varies from 25 to 91 mm.

The fourth width is at the conoid tubercle, which is at or close to the outer angle of the bone, though I have thought it wiser to take its distance from the point a in each case. The average width here is 18 mm., and the average distance from a 104 mm.

The last width is the greatest obtainable in the acromial third of the bone, and averages 21 mm.

With these widths the average contour of the left female clavicle from above may be completed (fig. 3), and in the same way, by taking the proper measurements recorded in the tables, the contours of the male bones (figs. 4 and 6) may be obtained.

The contour of the bone from in front shows so little constant curvature that I have not thought it worth while to estimate; though no doubt it could be done in the same way in which the antero-posterior

curves were measured; sometimes there is a distinct convexity upwards of the sternal two-thirds of the bone, while at others the central axis is practically a straight line.

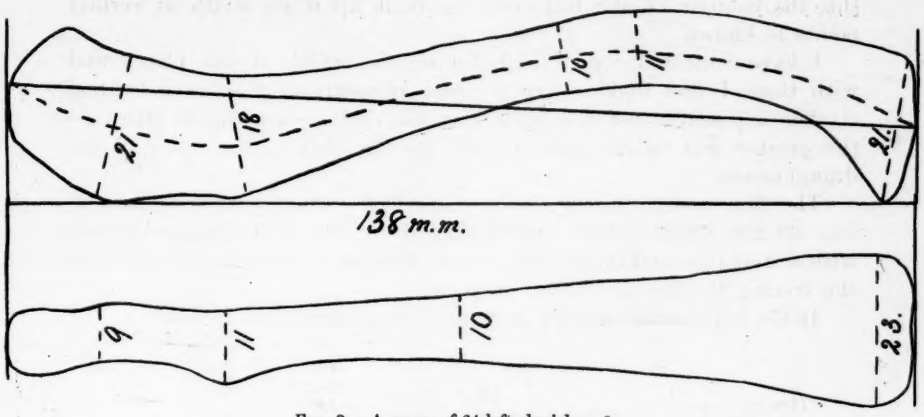


FIG. 3.—Average of 64 left clavicles, ♀.

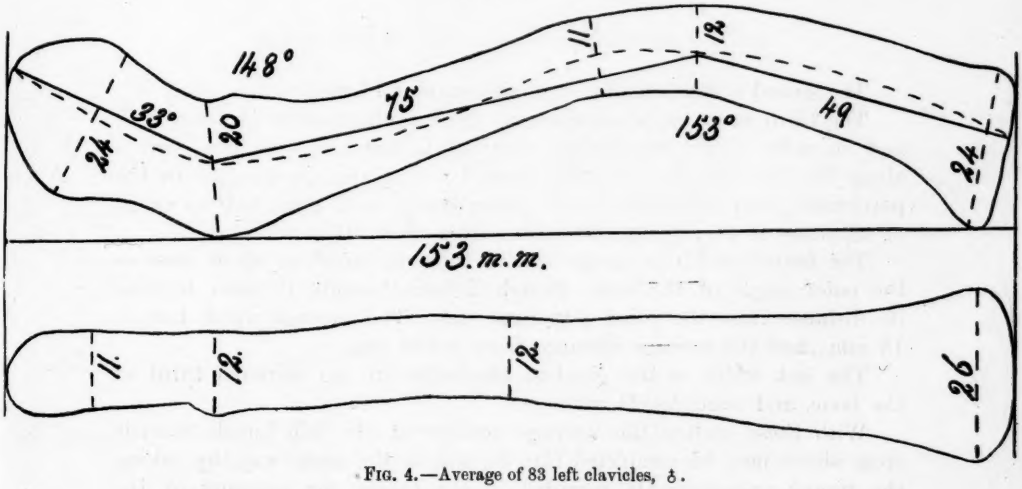


FIG. 4.—Average of 83 left clavicles, ♂.

I have satisfied myself with taking the depth at four places: firstly, the inner end; secondly, the middle of the bone; thirdly, at the conoid tubercle; and fourthly, the least depth of the acromial end. The average depths are recorded on the contours from in front in figs. 3, 4, 5, and 6.

Sex Characteristics of the Clavicle.

Since we are in possession of a fair number of clavicles, the sex of which is known, we can test the value of various possible sex characteristics.

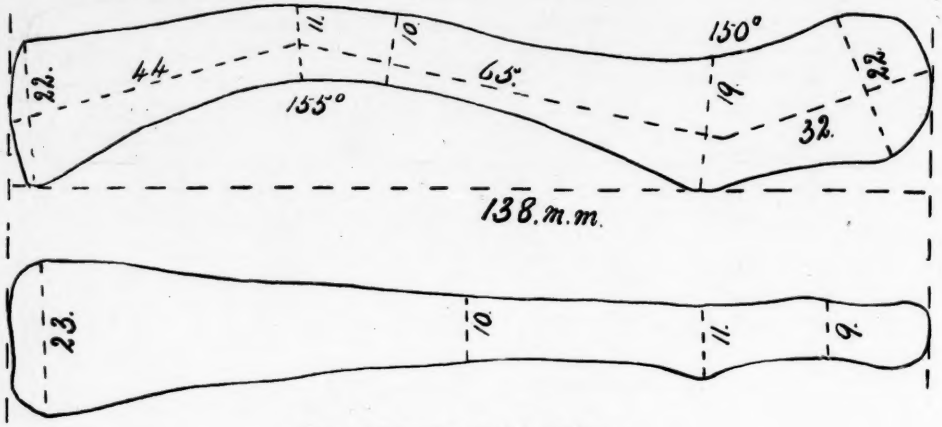


Fig. 5.—Average of 65 right clavicles, ♀.

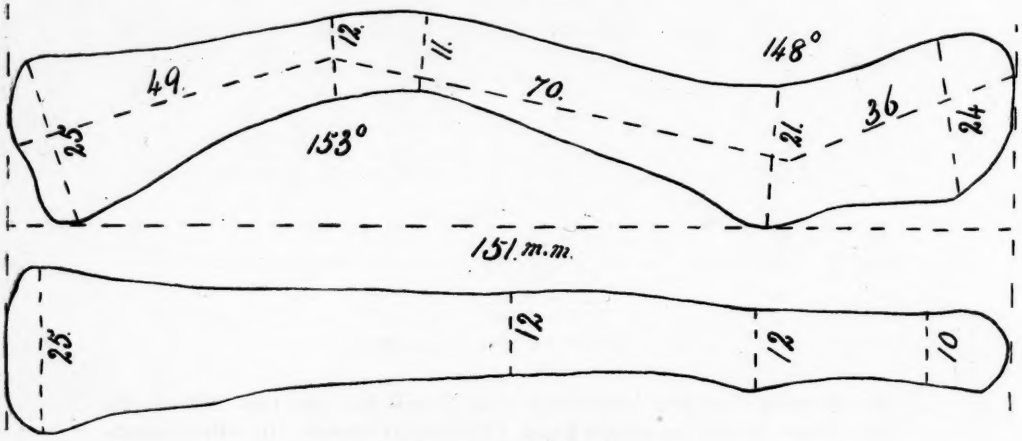
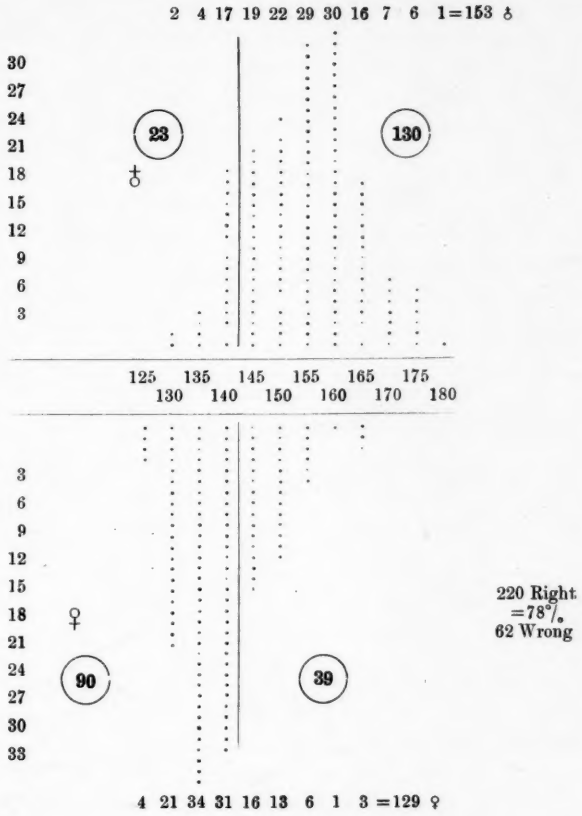


Fig. 6.—Average of 70 right clavicles, ♂.

Length.—As has been stated already, the average length of 70 male right clavicles is 151 mm., and of 83 left 153 mm.; while 64 left and 65 right female bones each averaged 138 mm. We may, therefore, con-

clude that the average male English clavicle averages 14 mm. more than the female in length, but when the lengths are arranged in a chart (chart 1) it is clear that the overlap is considerable. If we place

CHART No. 1.—CLAVICULAR LENGTHS.



the dividing line just below 145 mm. it will be seen that 262 of the 282 bones would be rightly, and 62 wrongly sexed. In other words, there would be an error of 22 per cent.

It must, however, be borne in mind that this chart does not give us a true estimate of the chances, because the number of female observations is only 129, while that of the males is 153. To get a just estimate we

must add 24—the difference between 153 and 129—to the female side of the chart and must distribute it proportionately to the size of the different columns on that side. When this is done the chances in favour of a bone under 145 mm. being female are as 106 to 23 instead of 90 to 23; that is to say, nearer 5 to 1 than 4 to 1.

On the other hand, a bone of 145 mm. or over is likely to be male in the proportion of less than 3 to 1 (2·6 : 1) instead of rather over 3 to 1.

The important thing to notice is that while the absence of equal numbers of the two sexes is regrettable, the lessons to be learnt from the chart would not be materially altered by the addition of another 24 female clavicles had they been available.

Of course we must take into account the fact that there are 24 fewer female than male bones, and if these are added in their proper proportion on each side of the vertical line the error remains the same.

It is clearly unwise to tie ourselves down to any one point in determining the sex of a bone, and, to me, the most common-sense course seems to take several characteristics and to find out by careful charting what are their relative values in order that, when a bone comes to be sexed, each characteristic may be given its proper numerical value.

Stoutness.—We know that the female clavicle is not only shorter but slighter than that of the male, and I have therefore decided to take the circumference of the bone at its middle, measured with a steel tape, and to plot out a chart in order to see what help in sexing a bone can be expected from it.

Chart No. 2 shows this arrangement, and if we take a line between 35 and 36 mm. as the arbitrary division we find that, of the 281 bones, 234 would be rightly sexed and 47 (16 per cent.) wrongly.

When the missing difference between the sexes of 23 female bones is supplied in its proper proportion the error is increased to 17 per cent., but it is clear that the circumference at the middle is a more valuable test of sex than is the length of the bone.

Size of the Inner End.—In many bones the size of the articular ends is regarded as a test of sex, and I have therefore determined to use the inner end of the clavicle.

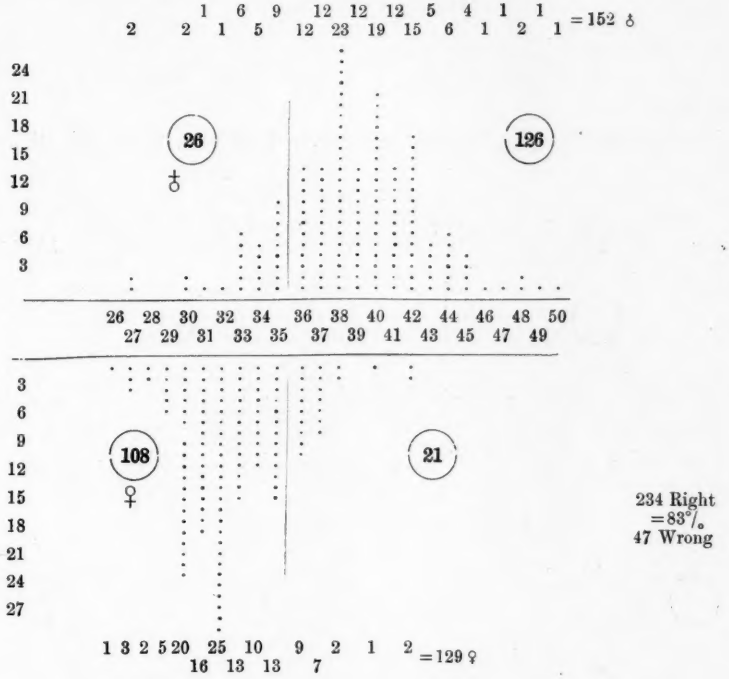
For practical purposes I found it better to add together the height and width of this part of the bone, determined by calipers, than to take its circumference with the steel tape. In the tables I have called this the "index of the inner end."

Chart No. 3 shows these measurements plotted out, and the dividing line has been drawn between 47 and 48.

This shows that 73 out of the 281 bones would have been wrongly sexed—an error of 26 per cent., which remains the same when the total numbers of the sexes are made even.

It is therefore evident that the circumference gives us 83 per cent. of successes, the length 77 per cent., and the inner end 74 per cent., but it is possible that by applying all three we may get better results still.

CHART No. 2.—CIRCUMFERENCE AT MIDDLE.



234 Right
=83%
47 Wrong

My method of doing this will be illustrated best, perhaps, by taking two or three examples.

Suppose we take a bone the length of which is 150 mm., the circumference 44 mm., and the end index 54: there can be no hesitation in presuming that it is male, because every one of the tests falls on the male side of the vertical dividing line in the charts; but if we take another the length of which is 154, the circumference 35, and the end index 40: it is male according to its length, though female both in circumference and end index, but

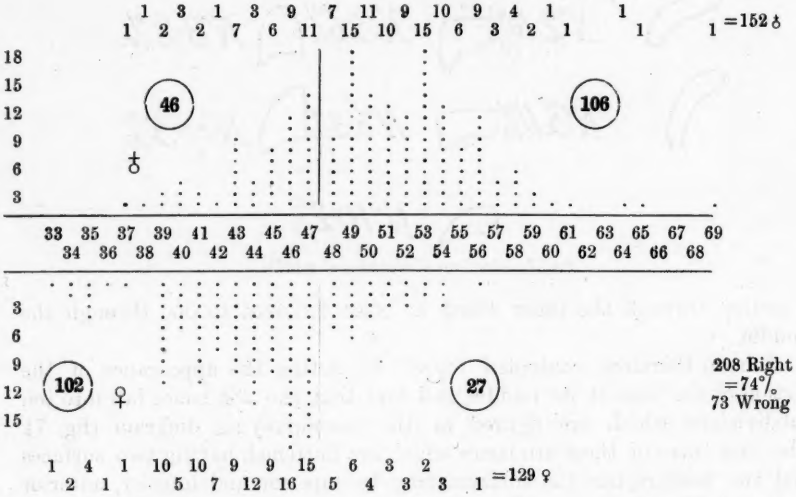
I should not place it among the females without valuing the points on each side. It is 10 points on the male side in length (the dividing line in chart 1 being between 144 and 145); it is one point on the female side in circumference, and eight points on the female side in end index—that is, ten chances of its being male to nine of its being female. But then these chances are not of equal value, and in order to get their true values I propose to divide each by its own coefficient of error, *i.e.*

$$\frac{10}{23} = \cdot 44\ ♂, \quad \frac{1}{17} = \cdot 06\ ♀, \quad \frac{8}{26} = \cdot 3\ ♀.$$

Adding the female points together we get ·44 in favour of the bone being male and ·36 in favour of its being female, or 0·8 in favour of the male sex altogether.

As a matter of fact this bone really was that of a male, but all cases

CHART No. 3.—INNER END INDICES.



are not equally happy, for there are a certain number of female bones which are markedly male in all three tests and vice versa.

Of course it is only a very small number of bones which require so careful an investigation as the example just taken, and in most cases a glance at their measurements determines the sex to which they should theoretically belong. When the 282 bones had been sexed in this way I found that I had made 34 mistakes—that I had sexed 88 per cent. correctly

and 12 per cent. wrongly. A greater mass of material might alter this, but I do not think greatly, since taking away 50 bones at random, *i.e.* in the order in which I got them, makes very little difference to the results.

Of course this is only an example of what can be done with modern English bones, and another race might need a quite different set of coefficients.

The Surfaces of the Clavicle.

Different authors have described the surfaces of the clavicle so differently that there is evidently a good deal of variation, and into this it may, perhaps, be worth while to inquire. Unfortunately, two observers might easily differ as to what surfaces were present in a particular clavicle, since

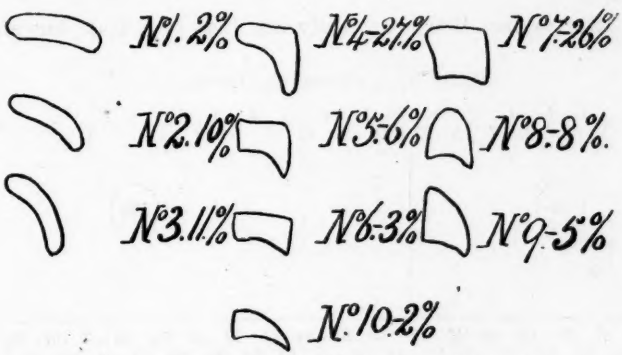


Fig. 7.—Sections of clavicles at middle.

a section through the inner third is often different to one through the middle.

I have therefore contented myself by noting the appearance of the section of the bone at its middle, and find that the 286 bones fall into ten subdivisions which are figured in the accompanying diagram (fig. 7). The first three of these are bones which are flattened, having two surfaces and two borders, but the surfaces may be superior and inferior, anterior and posterior, or intermediate. The fourth variety, which seems the commonest, is three-sided, with a definite superior, anterior, and postero-inferior surface, the latter being concave from above downward. The fifth, sixth, and seventh varieties are quadrilateral; while the eighth, ninth, and tenth are again triangular in section, but the surfaces are anterior, posterior, and inferior. It seems to me that most English clavicles are either triangular with one surface upward or quadrilateral with the posterior and inferior surfaces concave.

The Number of Nutrient Foramina.

It is well known that the clavicle, like the femur, often has two nutrient foramina. In the 286 bones which I examined I found it single in 64 per cent., double in 26 per cent., triple in 5 per cent., quadruple in 7 per cent. (2 specimens), while in 5 per cent. no definite foramen could be seen. In these latter cases, no doubt, the bone is nourished by the numerous small foramina at the sternal and acromial ends.

The position of the foramina is, as is well known, on either the posterior or inferior surface, or the border between them when both are present; but in eleven cases out of the 286 (nearly 4 per cent.) I found a very definite foramen on the anterior surface close to the outer limit of the attachment of the pectoralis major.

When there is more than one foramen a very common place for one of them is close to the trapezoid ridge on the lower surface.

Perforations in the Clavicle.

Most museums have specimens of the supraclavicular nerve piercing the clavicle. In the 286 bones which I examined I found seven specimens of this (2·5 per cent.), though, since in two cases the perforation was bilateral, the percentage overstates the frequency of its occurrence.

The curious thing about this perforation is that in every one of the seven cases it has a common opening at the back of the bone with the nutrient foramen. Sometimes it pursues quite a tortuous course through the bone, and almost invariably has a greater mass of bone below than above it.

Depression for the First Rib.

The frequency of this depression is not fully realised. If it is carefully looked for a more or less distinct concavity where the clavicle presses on the first rib, external to its junction with the cartilage, is present in 43 per cent. of all cases. It is, of course, quite distinct from the portion of the articular extremity which articulates with the first rib and has already been referred to as directed forwards as well as downwards. In order to distinguish the two it will perhaps be better to speak of the one under discussion as the "rhomboid depression," because it is close to the attachment of the rhomboid ligament.

Rhomboid Pit.—In 10 per cent. of my specimens I found a rough irregular depression for the attachment of the rhomboid ligament. In certain cases this pit was a centimetre in depth and penetrated half through the thickness of the bone.

Conoid Facet.—This facet is caused by the clavicle articulating with the coracoid process of the scapula close to its bend. It is not a common abnormality, and I only found four examples of it in my series.

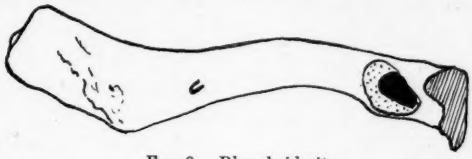


FIG. 8.—Rhomboid pit.

Trapezoid Tubercle.—The outer part of the trapezoid ridge is sometimes so accentuated as to form a very definite tuberosity, greatly increasing the apparent depth of the acromial end of the bone.

TABLE I.—FEMALE CLAVICLES—LEFT.

No.	No. of Subject.	Age.	Length of Clavicle.	Shoulder Width.	Proportion.	Curvature.			Segments.			Widths.					Depths.				Circumference at Middle.	Index of Inner End.
						Inner Angle.	Outer Angle.	Total Curvature.	Inner.	Middle.	Outer.	At Inner End.	At Inner Angle.	Least Width.	Distance.	At Conoid.	Distance.	At Outer End.	At Inner End.	At Middle.	At Conoid.	Least Outer Depth.		
1	1	...	125	354	353	151°	161°	312	35	60	32	22	11	10	39	18	92	23	23	9	11	9	31	45
2	8	...	150	370	405	149	141	290	49	75	33	21	10	10	48	18	119	20	25	10	13	8	31	46
3	10*	36	141	357	395	152	151	303	49	62	35	18	10	9	41	18	107	27	26	10	13	9	32	44
4	14	59	134	336	399	163	158	321	43	57	36	22	11	8	27	16	100	19	22	12	11	10	36	44
5	20	59	135	358	377	160	158	318	40	64	31	23	11	11	40	21	104	24	17	11	9	9	35	40
6	26	38	129	354	364	156	144	300	39	60	34	17	10	10	37	19	95	18	22	11	12	10	31	39
7	36	65	149	358	416	160	135	295	50	81	24	23	13	11	91	16	120	20	22	9	11	11	33	45
8	47	52	129	362	356	154	157	311	33	68	29	23	11	8	65	19	98	21	22	9	10	9	28	45
9	60	69	139	357	389	151	155	306	46	68	28	21	10	9	75	22	105	28	28	10	13	10	32	49
10	64	48	141	362	390	154	158	312	46	72	26	16	11	10	29	19	106	20	23	10	11	8	35	39
11	68	20	130	342	380	158	153	311	40	54	36	20	10	10	40	21	90	23	22	10	11	8	34	42
12	73*	45	142	367	387	154	156	310	41	71	33	23	10	10	45	15	110	20	24	10	12	9	30	47
13	79*	49	149	372	401	146	163	309	53	70	32	23	11	10	67	17	113	25	21	11	11	10	33	44
14	81*	46	134	377	355	152	138	290	45	64	28	21	10	10	55	16	98	15	22	8	10	7	30	43
15	82	28	133	330	403	159	154	313	37	67	30	20	8	8	37	17	95	16	24	10	11	9	32	44
16	83	31	139	385	361	153	159	312	36	71	35	20	11	10	48	24	104	29	24	11	11	11	33	44
17	87*	54	145	385	377	153	153	306	48	65	35	22	11	9	30	21	107	21	25	10	12	7	33	47
18	96*	46	155	351	441	150	145	295	53	75	34	21	11	10	36	16	120	16	22	10	11	6	34	43
19	98*	55	133	333	399	153	152	305	43	63	28	23	11	9	63	23	100	21	25	10	12	9	32	48
20	104*	44	127	348	365	156	143	299	38	60	32	21	9	8	48	18	96	22	20	9	12	11	30	41
21	105	70	133	344	387	141	148	289	45	68	27	22	13	12	71	19	98	19	24	9	11	10	32	46
22	106*	25	138	358	389	153	154	307	48	63	28	26	12	12	50	21	104	22	28	14	10	8	42	54
23	107*	36	134	375	357	157	156	313	44	56	35	25	13	10	68	21	98	25	27	12	15	12	36	52
24	108*	73	139	372	374	157	161	318	47	66	28	23	11	9	57	17	106	17	23	11	11	10	34	46
25	109*	40	149	370	403	153	163	316	53	69	30	22	10	9	80	19	102	18	22	9	10	10	32	44
26	110*	30	128	331	387	151	158	309	49	52	29	20	8	7	35	14	96	15	19	10	10	6	34	39
27	111*	46	136	330	412	152	142	294	38	71	32	21	11	9	57	18	101	17	22	9	11	8	38	43
28	112*	19	132	331	399	156	143	299	40	62	32	20	13	10	73	17	98	23	21	9	12	11	30	41
29	113*	52	139	...	...	156	133	289	39	76	30	17	10	9	83	14	113	18	16	8	10	9	29	33

30	123*	45	135	372	363	156	155	311	39	73	25	27	11	10	55	23	101	24	20	9	11	6	31	47
31	124*	67	142	372	382	156	160	316	47	67	31	23	12	11	37	21	107	25	24	10	9	8	35	47
32	126*	65	138	371	372	156	136	292	42	66	34	22	11	11	42	19	102	21	23	9	12	10	30	45
33	128*	60	133	357	373	147	149	296	44	64	31	20	10	10	42	18	100	20	26	10	10	11	35	46
34	136*	57	148	394	376	153	152	305	45	81	28	19	11	10	63	19	113	22	21	8	9	8	30	40
35	137*	64	136	405	336	147	149	296	45	72	25	20	10	9	33	13	104	16	22	9	10	8	31	42
36	138*	59	128	325	394	155	145	290	35	61	35	20	11	11	37	20	95	22	19	8	10	8	30	39
37	139*	73	140	377	371	156	152	308	35	69	39	23	12	10	60	19	102	23	25	11	11	10	34	48
38	140*	72	137	334	410	157	157	314	30	74	33	21	11	10	35	20	93	27	21	10	11	8	32	42
39	141*	39	136	353	395	156	154	310	35	71	32	20	12	10	53	24	99	25	20	10	9	9	30	40
40	142*	23	131	395	332	163	164	327	44	66	24	24	14	11	81	23	100	24	22	10	11	8	32	46
41	143*	26	134	342	392	157	157	314	45	66	26	20	11	9	35	18	104	22	21	10	12	11	31	41
42	144*	25	141	383	368	152	149	311	51	70	24	20	10	9	30	18	101	11	19	11	10	8	33	39
43	145*	27	128	339	378	153	149	302	40	60	28	20	11	10	25	19	98	20	22	11	10	9	33	42
44	146*	26	139	358	388	158	149	307	35	74	31	19	11	10	88	22	99	24	22	10	9	8	31	41
45	147*	58	140	402	348	154	140	294	44	69	32	27	11	10	75	14	107	23	26	10	11	11	31	53
46	148*	40	130	364	357	149	152	301	32	72	28	19	10	10	28	19	97	23	22	9	11	9	30	41
47	149*	64	150	366	410	156	157	313	46	80	28	23	11	10	36	20	115	27	20	10	11	7	32	43
48	150*	30	130	351	370	166	161	327	34	70	26	20	13	11	69	20	99	26	26	9	10	10	30	46
49	151*	38	154	413	373	151	141	292	53	64	42	26	12	12	67	15	117	14	28	12	11	10	35	54
50	153*	19	142	345	412	152	148	300	46	72	28	22	11	11	63	17	107	26	25	10	12	9	35	47
51	154*	48	129	359	359	159	156	315	39	64	30	21	12	9	77	18	103	21	27	11	9	8	32	48
52	156*	28	134	340	394	151	150	301	38	71	29	22	10	9	80	17	104	23	24	9	12	9	29	46
53	158*	24	162	413	392	159	136	295	50	88	25	23	12	12	73	20	121	25	24	10	12	10	35	47
54	159*	30	135	355	380	157	157	314	47	60	30	17	11	9	24	15	92	19	24	9	11	8	30	41
55	162*	32	137	370	370	164	163	327	42	67	30	20	12	12	68	15	106	25	21	8	9	7	29	41
56	174*	33	135	352	384	144	142	286	39	65	36	18	10	10	27	17	100	16	23	9	10	8	32	41
57	175*	35	162	375	433	154	146	300	45	81	40	20	11	10	64	17	121	19	24	10	12	9	32	44
58	176*	18	134	341	393	161	146	307	32	73	33	17	9	8	43	12	102	18	17	8	9	8	26	34
59	177*	24	121	306	295	161	141	302	25	68	33	18	11	9	63	13	93	15	17	9	11	10	27	35
60	179*	76	146	383	381	153	148	301	46	80	25	21	12	11	33	16	112	21	24	11	11	9	35	45
61	180*	32	149	363	410	155	144	299	39	74	39	22	10	9	53	20	111	21	22	10	12	9	31	44
62	181*	48	141	380	371	162	154	316	46	73	25	23	9	9	42	20	106	33	23	10	11	9	33	46
63	182*	38	141	362	390	162	146	308	45	76	24	17	11	10	30	18	110	22	22	9	15	11	29	39
64	183*	62	138	356	388	153	157	310	48	72	20	24	11	10	38	22	105	24	27	10	9	10	31	51
Average		44	138	361	383	155	151	306	42	69	30	21	11	10	52	18	104	21	23	10	11	9	32	44

* indicates that the corresponding bone of the opposite side is recorded in another table.

TABLE II.—FEMALE CLAVICLES—RIGHT

No.	No. of Subject.	Age.	Length of Clavicle.	Shoulder Width.	Proportion.	Curvature.			Segments.			Widths.						Depths.				Circumference at Middle.	Index of Inner End.
						Inner Angle.	Outer Angle.	Curvature.	Inner.	Middle.	Outer.	At Inner End.	At Inner Angle.	Least Width.	Distance.	At Conoid.	Distance.	At Inner End.	At Middle.	At Conoid.	Least Outer Depth.		
1	10*	36	147	357	412	156°	160°	316	53	63	33	19	10	9	26	24	109	23	27	12	11	9	38	46
2	11	20	135	327	413	156	161	317	47	73	18	22	10	9	68	20	101	21	21	9	10	8	30	43
3	19	29	149	342	436	154	163	317	53	67	31	19	10	10	51	20	111	19	21	9	10	7	32	40
4	23	42	124	347	360	158	142	300	35	57	37	23	9	9	49	18	89	23	20	13	15	8	37	39
5	24	56	137	357	384	145	155	300	49	61	31	23	11	10	72	20	104	21	22	9	11	10	31	45
6	27	35	133	379	351	162	160	322	43	61	31	24	9	9	62	24	96	21	28	9	10	8	32	52
7	39	53	132	372	355	152	156	308	51	58	27	26	11	10	75	20	99	24	28	11	13	11	37	54
8	42	28	126	344	366	159	144	303	40	62	29	23	11	9	51	12	97	18	24	8	9	6	31	47
9	43	50	153	346	442	156	154	310	50	72	33	25	10	10	71	23	115	25	26	13	14	13	37	51
10	45	48	138	372	371	155	145	298	46	63	33	23	10	9	26	21	106	23	26	11	13	10	40	49
11	48	56	145	350	414	150	158	308	44	72	33	24	10	8	70	18	118	23	23	11	10	9	30	47
12	51	40	133	359	370	157	145	302	39	57	39	23	10	10	36	20	95	25	23	10	12	12	35	46
13	53	58	137	368	372	155	157	312	48	59	34	22	9	9	48	19	103	22	25	11	13	11	37	47
14	56	48	151	388	389	158	155	313	47	71	34	23	12	11	83	28	110	30	27	10	13	12	36	50
15	73*	45	143	367	389	152	148	300	42	70	37	25	10	10	74	15	109	20	25	9	12	10	32	50
16	79*	49	144	372	387	148	158	306	51	63	36	23	12	10	71	20	105	23	20	11	11	9	33	43
17	81*	46	135	377	361	152	134	286	49	71	25	21	12	10	73	14	103	15	19	7	10	8	30	40
18	84	48	130	362	359	163	157	320	35	68	29	23	10	8	61	19	100	22	22	10	10	10	30	45
19	87*	54	146	385	379	155	162	317	55	58	37	23	11	10	76	24	110	23	24	11	11	8	36	47
20	96*	46	155	351	442	152	144	296	55	72	31	22	10	10	35	16	116	20	20	11	10	6	34	42
21	98*	55	130	333	390	153	153	306	44	59	30	22	10	9	62	19	95	19	25	11	11	8	32	47
22	104*	44	132	348	379	155	146	301	44	59	34	23	8	7	66	16	99	20	20	10	12	10	30	43
23	106*	25	131	358	366	151	149	300	43	61	30	24	11	11	42	21	95	23	25	12	11	8	42	49
24	107*	36	138	375	368	151	154	305	45	64	34	25	13	10	58	19	104	24	24	11	14	10	36	49
25	108*	73	135	372	363	153	159	312	51	61	27	22	12	11	31	20	102	20	23	11	12	10	34	45
26	109*	40	143	370	386	149	162	311	51	63	30	22	11	9	71	17	108	21	25	11	11	10	32	47
27	110*	30	126	331	381	150	155	305	48	52	31	18	9	9	36	16	95	15	17	11	10	6	34	35
28	111*	46	128	330	388	157	132	289	33	65	32	23	12	12	48	18	96	20	24	9	12	9	31	47
29	112*	19	132	331	400	165	150	315	33	70	30	23	14	9	63	19	99	24	21	9	12	10	30	44

30	113*	52	140	...	...	154	133	287	47	68	33	19	10	9	27	19	110	19	17	8	10	8	29	36
31	123*	45	131	372	252	152	150	302	38	66	31	25	10	10	42	23	97	24	22	11	11	9	35	47
32	124*	67	144	372	387	171	155	326	44	62	39	26	12	11	51	10	106	23	23	11	9	9	37	49
33	126*	65	135	371	364	156	138	294	33	73	31	24	10	9	39	18	100	22	22	9	11	9	30	46
34	128*	60	129	357	362	154	141	295	43	59	32	22	11	11	42	20	93	20	24	11	13	12	36	46
35	136*	57	148	394	376	155	163	318	48	70	36	19	11	11	53	20	110	28	22	9	10	7	32	41
36	137*	64	133	405	328	154	143	297	49	64	25	25	10	9	35	12	101	17	23	10	10	10	32	48
37	138*	56	129	325	397	151	149	300	45	58	30	21	11	11	40	21	99	24	21	9	9	8	32	42
38	139*	73	139	377	369	157	152	309	36	67	39	25	11	10	46	20	105	25	24	11	12	9	36	49
39	140*	72	137	334	410	153	140	293	35	74	30	20	15	11	53	21	99	26	21	10	10	8	32	41
40	141*	39	138	353	391	154	155	309	39	67	35	22	13	10	56	20	99	25	22	10	11	9	33	44
41	142*	23	129	395	327	156	161	317	46	62	24	24	11	11	58	23	97	25	21	10	11	9	33	45
42	143*	26	135	342	395	163	150	313	42	65	30	19	12	11	50	21	105	21	18	11	12	10	34	37
43	144*	25	139	383	363	151	149	300	50	58	34	18	11	9	35	13	105	19	24	12	10	7	35	42
44	145*	27	129	339	381	154	154	308	41	61	30	18	10	10	45	19	99	24	21	11	11	9	33	39
45	146*	26	138	358	386	154	154	308	45	64	32	23	12	11	77	21	98	24	23	10	9	9	32	46
46	147*	58	133	402	331	156	139	295	42	62	27	25	10	8	57	18	103	27	28	10	11	11	30	53
47	148*	40	126	364	346	150	142	292	41	55	35	21	11	9	28	20	95	26	23	9	12	10	32	44
48	150*	30	133	351	379	161	170	331	43	65	26	18	11	10	26	20	103	28	25	10	10	9	31	43
49	151*	38	154	413	373	148	144	292	50	75	36	28	12	12	60	17	117	18	28	11	10	10	36	56
50	153*	19	140	345	406	151	143	294	41	68	36	21	12	12	41	19	107	21	25	10	13	11	37	46
51	154*	48	129	359	359	160	146	306	34	59	39	20	13	10	72	18	100	20	23	11	9	11	33	43
52	156*	28	136	340	400	154	143	297	39	68	32	23	11	10	49	17	104	22	23	10	12	10	30	46
53	158*	24	164	413	397	162	149	311	45	80	43	25	11	11	47	16	121	23	25	12	13	10	36	50
54	159*	30	131	355	369	155	153	308	43	59	28	18	10	9	57	19	99	20	21	9	11	8	28	39
55	162*	32	142	370	384	160	148	308	42	75	25	23	12	12	55	17	104	24	24	8	8	8	32	47
56	174*	33	135	352	384	143	132	275	51	55	36	14	10	11	31	15	102	17	21	12	10	8	37	35
57	175*	35	160	375	427	151	150	301	51	75	40	22	13	12	40	19	117	21	24	10	11	9	32	46
58	176*	18	132	341	387	161	149	310	37	68	31	18	8	8	55	15	102	18	17	8	9	8	27	35
59	177*	24	124	306	405	163	151	314	37	59	30	17	10	9	53	17	96	19	17	8	10	10	27	34
60	178	22	136	344	395	153	132	285	45	68	30	16	12	10	84	16	110	18	23	10	10	9	33	39
61	179*	76	148	383	386	155	156	311	49	68	34	27	11	11	44	20	107	23	24	11	10	9	35	51
62	180*	32	145	363	399	154	145	299	44	69	34	24	11	10	70	20	107	21	24	11	12	9	31	48
63	181*	48	137	380	361	161	148	309	52	63	25	24	11	10	41	17	104	19	26	11	11	10	35	50
64	182*	38	138	362	381	160	146	306	44	65	30	21	12	12	59	19	107	24	23	10	14	11	31	44
65	183*	62	139	356	390	156	160	316	57	57	29	25	10	9	36	22	109	24	27	11	10	9	34	52
Average		43	138	361	382	155	150	305	44	65	32	22	11	10	52	19	104	22	23	10	11	9	33	45

TABLE III.—MALE CLAVICLES—LEFT.

No.	No. of Subject.	Age.	Length of Clavicle.	Shoulder Width.	Proportion.	Curvature.			Segments.			Widths.							Depths.				Circumference.	Index of Inner End.
						Inner Angle.	Outer Angle.	Total Curvature.	Inner.	Middle.	Outer.	At Inner End.	At Inner Angle.	Least Width.	Distance.	At Conoid.	Distance.	At Outer End.	At Inner End.	Middle.	At Conoid.	Least Outer Depth.		
1	3	...	139	365	381	153°	133°	286	34	71	35	21	11	9	61	17	99	17	26	9	10	8	30	47
2	4	...	147	377	390	162	148	310	43	72	30	26	14	13	73	16	112	17	28	13	11	10	42	54
3	5	...	148	385	384	159	155	314	53	69	30	27	13	11	82	22	111	22	27	14	14	11	40	54
4	6	...	152	384	396	154	155	309	52	67	35	21	11	11	65	22	112	23	24	13	13	11	35	45
5	9	...	160	406	394	151	149	300	53	74	31	22	13	11	70	17	116	17	28	10	11	10	33	50
6	12	...	140	363	386	149	148	297	42	68	35	25	14	12	76	19	102	19	21	10	10	8	33	46
7	16	70	165	421	392	157	153	310	47	87	31	28	13	10	73	20	120	27	29	13	10	11	40	57
8	18	48	153	410	373	152	149	301	50	82	24	25	13	12	61	24	112	29	29	13	11	9	40	54
9	21	67	149	387	385	154	139	293	36	80	36	22	13	11	78	21	104	26	27	12	13	9	37	49
10	28	43	165	400	413	151	139	290	50	88	30	29	15	13	83	27	118	27	32	12	13	11	42	61
11	30	58	161	398	405	149	144	293	55	84	29	29	13	12	36	27	120	31	27	15	11	12	42	56
12	32	42	153	402	381	140	156	296	60	69	29	25	15	13	85	20	108	22	27	14	13	13	45	52
13	33	20	153	383	399	159	148	307	40	74	35	28	13	11	72	17	108	29	28	9	11	12	35	56
14	35	21	162	407	398	158	142	300	42	89	31	23	12	11	73	17	122	24	29	12	11	9	37	52
15	37	31	162	449	361	160	162	322	45	79	37	23	11	11	67	20	119	20	26	13	13	12	40	49
16	46	29	159	429	371	156	154	310	51	70	41	27	11	11	70	19	104	27	24	13	13	12	37	51
17	49	30	145	382	380	162	147	309	32	83	33	21	16	12	77	18	104	24	22	15	18	10	41	43
18	50	59	138	353	391	155	152	307	47	60	32	25	11	9	73	19	100	22	24	11	13	11	36	47
19	52	36	149	400	373	166	131	297	38	88	28	28	11	11	37	20	113	25	25	12	15	12	38	53
20	54	47	151	411	367	167	139	306	52	64	37	24	12	11	64	21	113	24	25	15	14	13	39	49
21	55	43	150	418	359	160	136	296	44	77	32	25	13	12	37	19	113	26	30	15	13	12	43	55
22	58	48	154	408	377	149	153	302	54	72	32	26	12	11	48	21	110	24	26	15	16	14	42	52
23	61	32	160	393	407	156	147	303	52	79	32	24	12	10	32	20	123	23	23	12	12	8	38	47
24	62	60	147	377	390	153	154	307	49	70	30	18	13	11	29	20	117	24	24	13	14	12	38	42
25	65	33	155	404	384	152	129	281	49	82	27	29	11	11	70	20	119	29	27	14	14	14	41	56
26	66*	18	130	369	352	158	151	309	46	52	32	21	11	10	60	14	96	20	18	10	11	11	30	39
27	69*	26	159	392	406	150	149	299	52	72	38	22	9	9	52	19	112	19	22	13	13	11	41	44
28	70	50	140	401	349	146	159	305	46	67	32	23	12	10	63	18	101	22	...	...	...	...	...	...
29	71*	31	151	394	388	159	154	313	49	68	33	22	13	11	56	20	110	27	24	12	12	10	39	46
30	72*	56	147	374	393	153	149	302	54	65	30	29	10	9	48	24	106	26	21	14	11	9	39	50
31	74	58	137	378	362	155	150	305	43	63	33	27	11	10	60	22	102	22	26	14	12	10	40	53
32	75*	38	157	364	431	158	156	314	53	70	35	24	10	9	83	15	112	19	22	12	10	10	32	46
33	77	28	162	409	396	154	149	303	46	81	35	24	13	12	68	24	120	24	27	13	11	9	38	51
34	78	43	152	405	375	159	156	315	38	81	33	22	12	12	58	20	112	28	27	13	13	11	40	49
35	80	58	153	423	362	153	146	299	47	73	36	28	11	11	54	18	111	20	27	14	12	11	41	55
36	85*	29	157	414	379	157	144	301	50	74	38	22	13	12	87	17	120	24	27	12	12	9	36	49
37	86*	51	155	419	370	157	151	308	49	76	34	20	12	12	50	20	114	26	26	11	12	11	38	46

38	90*	old	140	410	341	154	146	300	40	68	37	25	11	10	54	17	104	22	24	10	13	9	37	49
39	91*	72	157	392	401	148	141	289	49	75	38	23	12	12	70	23	119	20	22	10	13	10	35	45
40	92*	68	143	407	351	134	144	278	56	63	32	19	12	10	76	19	101	24	21	13	12	12	33	40
41	93	43	151	382	395	147	156	303	56	71	28	27	14	12	85	18	116	23	29	12	12	11	38	56
42	94*	59	165	419	394	163	144	307	42	83	42	28	12	12	65	17	118	25	30	13	16	17	42	58
43	95*	59	140	373	375	148	132	280	45	68	35	27	14	11	80	17	108	26	25	12	14	14	35	52
44	97*	59	167	429	389	161	152	313	49	83	38	29	13	12	72	17	123	23	27	12	12	10	38	56
45	99*	39	156	409	381	150	150	300	60	64	33	23	11	10	33	17	117	27	26	11	13	8	37	49
46	100*	56	145	363	399	151	154	305	47	69	31	25	13	9	70	18	107	24	28	12	12	12	34	53
47	101*	20	151	394	383	155	146	301	43	76	33	25	10	10	53	16	113	20	24	11	9	9	33	49
48	102*	19	158	415	381	154	153	307	55	71	33	25	12	12	70	20	123	26	25	13	12	11	40	50
49	103*	48	156	403	387	145	141	286	57	76	29	26	12	12	65	25	122	28	27	14	14	9	42	53
50	114*	68	149	413	361	154	120	274	39	82	30	34	12	11	83	19	110	23	35	13	13	11	39	69
51	115*	51	140	367	381	150	155	305	45	61	36	20	11	10	70	22	102	20	23	13	13	11	36	43
52	116	50	166	422	393	145	147	292	53	85	36	26	10	9	77	24	123	29	24	12	12	9	35	50
53	117*	43	172	436	394	153	143	296	59	91	25	19	13	12	35	17	134	17	28	10	11	9	38	47
54	118*	71	153	383	399	157	158	315	46	70	42	28	11	11	52	24	113	25	31	13	12	12	40	59
55	119*	65	156	450	347	161	147	308	45	77	40	29	14	10	78	20	122	27	27	14	15	12	41	56
56	120*	27	154	401	384	152	151	303	49	76	31	20	13	10	74	16	119	22	27	10	8	7	34	47
57	121*	60	150	398	377	153	125	278	41	86	25	27	13	11	58	15	113	24	25	13	12	12	40	52
58	122*	55	149	409	364	152	148	300	49	68	35	22	12	11	33	18	111	21	24	12	12	10	39	46
59	125*	57	145	396	366	151	153	304	46	69	34	28	14	13	73	21	103	24	26	12	14	11	41	54
60	127*	28	161	378	426	146	151	297	49	81	35	22	13	11	69	20	120	27	25	13	10	8	37	47
61	129*	52	149	380	392	153	149	302	52	59	41	22	12	11	60	20	106	21	28	12	10	9	37	50
62	130*	50	158	403	370	151	151	302	50	83	29	21	11	10	70	18	115	20	26	12	10	10	36	47
63	131*	23	140	340	412	152	140	292	39	82	25	20	9	9	30	17	111	20	20	8	9	6	27	40
64	132*	54	154	402	383	156	154	310	57	67	31	26	14	13	38	25	111	27	27	12	10	10	43	53
65	133*	42	147	404	364	151	149	300	49	78	22	24	12	11	70	19	112	22	30	11	12	11	38	54
66	134*	49	140	403	347	158	149	307	48	64	30	21	9	9	55	17	110	18	22	12	13	13	34	43
67	135*	30	147	401	367	153	146	299	53	70	25	24	14	12	87	20	107	26	27	10	9	8	38	51
68	152*	52	159	403	395	151	155	306	45	87	29	26	14	13	75	21	110	28	27	13	12	9	42	53
69	155*	30	156	397	393	157	143	300	50	72	37	25	14	14	47	18	118	22	25	12	13	11	46	50
70	157	40	152	371	410	150	155	305	52	74	30	20	12	11	84	20	113	24	23	10	11	8	35	43
71	160*	23	176	427	412	149	152	301	60	81	40	24	13	12	35	22	133	26	26	12	13	10	44	50
72	161*	39	146	373	392	156	142	298	52	66	30	22	13	13	28	20	108	21	29	13	11	9	42	51
73	163*	34	142	365	389	151	153	304	53	57	38	22	12	12	63	15	110	20	21	10	10	9	34	43
74	164*	64	172	455	378	160	145	305	55	83	36	24	12	12	61	20	133	28	30	13	12	10	40	54
75	165*	66	160	420	381	150	149	299	49	88	27	25	14	11	82	19	119	28	31	11	11	9	36	56
76	166*	19	144	380	379	154	160	314	48	75	23	19	13	12	33	23	105	27	22	11	11	9	37	41
77	167*	33	173	420	412	150	144	294	57	85	33	25	16	15	15	22	129	23	28	12	12	11	44	53
78	168*	41	148	360	411	146	142	288	46	74	33	22	13	12	42	18	111	24	29	11	15	10	40	51
79	169*	34	158	405	390	144	151	295	45	81	36	29	16	13	71	19	117	31	29	16	14	12	48	58
80	170*	50	158	401	394	153	150	303	49	79	34	23	11	10	74	20	125	25	32	11	12	10	33	55
81	171*	64	155	394	393	146	132	278	46	81	35	23	14	12	86	17	112	23	25	13	15	11	39	48
82	172*	33	171	402	425	151	161	312	60	70	39	23	12	11	48	21	120	34	22	11	14	10	40	45
83	173*	43	164	392	418	156	153	309	50	76	41	20	12	11	22	20	127	24	24	13	12	10	38	44
Average		45	153	398	385	153	148	301	49	75	33	24	12	11	61	20	113	24	26	12	12	11	38	50

TABLE IV.—MALE CLAVICLES—RIGHT.

No.	No. of Subject.	Age.	Length of Clavicle.	Shoulder Width.	Proportion.	Curvature.			Segments.			Widths.							Depths.				Circumference.	Index of Lower End.
						Inner Angle.	Outer Angle.	Index of Curvature.	Inner.	Middle.	Outer.	At Inner End.	At Inner Angle.	Least Width.	Distance.	At Conoid	Distance.	At Outer End.	At Inner End.	At Middle.	At Conoid.	Least at Outer End.		
1	2	...	156	394	396	151°	154°	305	46	70	42	22	13	11	70	20	113	26	21	13	11	8	40	43
2	7	...	154	385	400	152	154	306	50	70	38	22	12	11	87	22	115	22	25	13	12	11	40	47
3	13	58	154	389	396	141	156	297	47	73	37	25	13	12	81	18	107	25	25	12	12	10	37	50
4	15	52	162	413	392	149	145	294	51	74	43	26	12	12	60	26	118	22	27	12	13	11	39	53
5	17	41	166	431	385	158	144	302	48	90	29	24	13	13	80	22	124	23	25	11	12	11	36	49
6	22	64	143	404	354	155	140	295	44	66	36	24	15	12	65	17	108	22	28	13	12	10	40	52
7	25	47	141	389	362	151	150	301	45	63	32	29	12	11	34	20	115	29	25	15	14	12	44	54
8	31	28	154	424	363	150	171	321	55	68	31	27	12	12	55	26	109	34	27	13	13	12	41	54
9	34	...	139	387	359	147	145	292	44	67	32	22	13	12	32	23	99	27	29	13	14	12	42	51
10	38	22	154	400	385	155	146	301	48	76	33	19	15	12	78	17	118	18	21	11	11	11	35	40
11	40	48	141	382	369	156	153	309	47	59	37	25	12	12	45	26	98	28	28	13	10	10	41	53
12	41	68	148	402	368	153	150	303	52	59	39	30	14	13	60	22	106	25	26	15	15	12	45	56
13	44	36	148	392	378	137	150	287	48	63	40	25	14	12	70	23	104	25	23	13	13	10	41	48
14	57	26	162	428	379	158	170	328	55	70	39	22	12	10	66	23	125	34	29	12	13	10	39	51
15	59	56	155	419	370	155	156	311	46	72	35	21	12	11	67	19	118	23	25	12	14	12	40	46
16	63	49	140	356	393	148	163	311	47	63	30	25	13	13	52	24	98	24	24	14	11	8	42	49
17	66*	18	126	369	341	149	150	299	44	50	35	20	11	10	60	15	95	19	18	10	10	10	31	38
18	67	60	161	425	397	153	141	294	60	63	40	30	17	15	40	32	115	30	28	13	15	14	47	58
19	69*	26	158	392	403	150	152	302	58	64	42	28	9	9	52	19	115	19	22	14	12	11	42	50
20	71*	31	153	394	388	154	153	307	54	73	29	25	13	12	41	23	113	29	27	14	12	9	39	52
21	72*	56	145	374	388	155	161	316	58	51	36	28	11	11	55	22	102	29	25	11	11	9	38	53
22	75*	38	160	364	439	158	161	319	58	75	30	24	10	9	69	18	118	20	26	12	10	9	33	50
23	76	50	152	398	382	156	137	293	43	78	31	26	13	12	65	23	118	20	26	11	14	10	35	52
24	85*	29	160	414	386	156	152	308	47	80	36	23	11	10	53	19	119	25	26	12	11	9	38	49
25	86*	51	155	419	370	157	141	298	48	76	35	22	11	10	37	19	124	25	24	13	13	11	38	46
26	88	34	140	377	371	150	139	289	40	81	23	19	15	12	62	17	116	18	20	9	10	10	33	39
27	89	36	132	370	357	161	148	309	48	52	34	20	9	9	49	16	100	20	23	12	14	11	35	43
28	90*	old	140	410	341	145	143	288	48	59	40	25	12	11	69	21	102	23	20	12	13	11	41	45
29	91*	72	153	392	390	154	145	299	51	61	43	28	12	11	38	23	110	20	25	15	13	11	36	53
30	92*	68	143	407	351	139	147	286	54	59	35	24	12	11	72	18	117	23	23	14	17	11	38	47
31	94*	59	160	419	382	159	145	304	42	73	48	27	13	12	65	23	114	25	30	14	15	16	45	75

32	95°	59	135	373	362	149	133	282	41	65	37	26	13	11	70	17	107	25	25	13	17	13	38	51
33	97°	59	167	429	389	159	156	315	57	69	42	30	12	12	68	18	121	27	25	13	13	11	43	55
34	99°	39	149	409	364	161	146	307	56	61	31	25	12	11	50	18	112	22	27	12	16	9	36	52
35	100°	56	140	363	386	151	153	304	42	57	37	27	12	10	65	20	105	26	26	14	13	11	39	53
36	101°	20	144	394	365	156	149	305	50	62	33	24	11	11	50	20	105	20	23	12	9	10	38	47
37	102°	19	160	415	386	157	150	307	53	74	49	28	12	11	44	20	119	22	26	11	12	11	43	54
38	103°	48	149	403	370	153	161	314	61	67	35	24	13	12	73	24	123	26	27	18	13	10	50	51
39	114°	68	156	413	378	158	128	286	48	76	31	32	12	10	80	17	115	23	33	11	15	11	38	65
40	115°	51	145	367	395	152	148	300	40	71	36	24	13	12	58	23	106	25	22	12	13	10	37	46
41	117°	43	168	436	385	152	144	296	57	80	36	23	14	14	63	18	132	16	26	11	11	9	40	49
42	118°	71	154	383	402	160	158	318	46	68	42	27	12	11	55	22	115	27	31	13	13	11	42	58
43	119°	65	161	450	358	164	148	312	32	90	42	27	15	11	51	20	122	25	30	12	13	12	42	57
44	120°	27	146	401	364	148	145	293	46	70	33	20	11	10	64	18	110	23	24	12	8	8	37	44
45	121°	60	142	398	357	143	136	279	38	81	31	20	13	10	73	16	109	22	25	11	12	10	39	51
46	122°	55	145	409	355	156	141	297	40	70	39	26	12	11	75	16	106	19	23	10	12	11	36	49
47	125°	57	143	396	361	158	157	315	47	59	40	28	11	11	51	21	103	23	25	15	11	10	43	53
48	127°	28	160	378	423	158	145	303	45	85	33	22	11	10	52	26	118	27	26	13	11	8	38	48
49	129°	52	143	380	376	155	139	294	49	53	40	26	13	13	62	18	99	23	29	12	11	9	38	55
50	130°	50	157	403	390	155	144	299	53	74	33	23	11	11	70	17	118	19	25	13	11	10	38	48
51	131°	23	139	340	409	154	144	298	46	66	33	16	9	7	29	17	108	21	21	8	9	7	27	37
52	132°	54	151	402	376	153	146	299	58	56	40	30	14	13	50	26	106	26	26	11	12	11	45	56
53	133°	42	148	404	366	151	143	294	51	72	30	24	12	10	68	19	109	23	29	11	12	10	36	53
54	134°	49	132	403	328	156	143	299	50	55	30	25	11	10	42	17	100	21	24	11	14	14	36	49
55	135°	30	138	401	344	156	153	309	48	59	30	25	13	13	52	25	106	29	28	11	12	9	38	53
56	152°	52	157	403	390	155	156	311	45	83	32	28	15	13	66	24	117	27	26	14	12	9	44	54
57	155°	30	157	397	395	154	148	302	51	68	40	23	14	13	34	21	121	23	24	13	14	11	48	47
58	160°	23	175	427	410	151	150	301	59	84	37	24	13	12	40	20	131	23	24	13	14	9	39	48
59	161°	39	144	373	386	153	148	301	50	67	30	21	13	11	37	23	107	27	27	11	12	9	44	48
60	163°	34	134	365	367	155	146	301	38	63	35	24	11	11	45	16	102	28	21	10	12	10	34	45
61	164°	64	167	455	367	162	144	306	51	81	38	31	12	12	48	21	124	27	29	12	12	10	44	60
62	165°	66	161	420	383	152	152	304	56	79	30	30	14	13	84	23	121	32	29	13	10	10	42	59
63	166°	19	142	380	374	152	153	305	46	68	32	21	13	12	70	21	109	24	20	10	10	9	36	41
64	167°	33	167	420	398	152	137	289	55	87	30	25	16	16	71	22	127	29	25	13	13	10	41	50
65	168°	41	148	360	411	147	139	286	56	69	28	21	13	13	49	21	113	24	24	12	15	10	42	45
66	169°	34	156	405	385	153	144	297	52	71	39	31	11	10	35	23	117	29	33	13	15	13	49	64
67	170°	50	161	401	401	153	144	297	48	83	36	25	13	12	63	22	125	27	30	12	11	10	37	55
68	171°	64	156	394	396	152	152	304	48	68	44	23	12	11	78	20	113	23	23	13	14	11	40	46
69	172°	33	173	402	430	152	146	298	51	83	42	21	12	12	52	21	127	29	27	12	13	11	41	48
70	173°	43	164	392	418	158	148	296	47	83	39	24	13	11	35	22	127	25	25	12	11	9	40	49
Average		45	151	398	381	153	148	301	49	70	36	25	12	11	58	21	113	24	25	12	12	10	40	50